# THE GEOGRAPHICAL REVIEW

## CONTENTS FOR APRIL, 1933


PAGE

The Flight to Marie Byrd Land . . . . . 177
*By Rear Admiral Richard E. Byrd*
With a Description of the Map
*By Commander Harold E. Saunders*

The Rainy Season of 1932 in Southwestern Ecuador . . 210
*By George Sheppard*

The Littoral of Northern California as a Geographic Province 217
*By J. W. Hoover*

The Black Man's Industries . . . . . 230
*By Robert H. Forbes*

Climatic and Physiographic Notes on French Guinea . . 248
*By E. F. Gautier*

A World Map of Tides . . . . . 259
*By Hubert A. Bauer*

Rio de Janeiro and São Paulo . . . . . 271
*By Preston E. James*

Recent Major Oceanographic Expeditions: A Review of the Work of the Meteor, Carnegie, Dana, and Snellius Expeditions . . . . . 299
*By H. A. Marmer*

The Guatemala-Honduras Boundary . . . . . 306

Twenty-Ninth Annual Meeting of the Association of American Geographers . . . . . 310

American Geographical Society . . . . . 314

Geographical Record (*listed on the next page*) . . . . . 323

Geographical Reviews (*listed on the next page*) . . . . . 339



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PUBLISHED QUARTERLY BY THE AMERICAN GEOGRAPHICAL SOCIETY
BROADWAY AT 156TH STREET, NEW YORK, N. Y.

*Price*, $1.25 a number Five dollars a year

Entered as second-class matter, January 22, 1916, at the Post Office at New York, N. Y., under the Act of August 24, 1912

Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on July 30, 1918

## GEOGRAPHICAL RECORD


NORTH AMERICA

The Vote by Counties in the Presidential Election of 1932 ..... 323

SOUTH AMERICA

Minerals and Water Power in Brazil. *By Preston E. James* ..... 324
Town-Planning for Nictheroy ..... 325
The Chipayas of Bolivia. *By W. E. Rudolph* 326

AFRICA

A New Map of French North Africa ..... 326
The "Suqs" of Morocco ..... 327
The Seasons in Senegal ..... 327
Some Recent Journeys in the French Sahara ..... 328

ASIA

Land Tenure and Oil Concessions in 'Iraq. 329
The Rainfall of Turkey ..... 330
Woodland and Pasture in Northern Turkey 331
The Physiographic Regions of Arabia ..... 331
Explorations of Philby, Rutter, and Sadek Bey in Arabia ..... 332
A Daytime Census in Tokyo and the Center of Population in Hokkaido. *By Mark Jefferson* ..... 333

POLAR REGIONS

The Norsemen's Farthest North in Greenland. *By H. Hermannsson* ..... 334
Completion of the Scientific Results of the Gauss Antarctic Expedition ..... 335

WORLD AS A WHOLE AND LARGER PARTS

Irrigation in the Caspian Lowlands. *By W. C. Lowdermilk and N. Mirov* ..... 336

HISTORICAL GEOGRAPHY

The Tide in Ancient Science ..... 337

GEOGRAPHICAL NEWS

Sixteenth Session of the International Geological Congress ..... 338

OBITUARY

Henry Grier Bryant ..... 338


## GEOGRAPHICAL REVIEWS


P. CAMENA D'ALMEIDA. **États de la Baltique—Russie.** *By R. M. Fleming* ..... 339

HANS VON ECKHARDT. **Russia.** *By R. M. Fleming* ..... 339

LANCELOT LAWTON. **An Economic History of Soviet Russia.** *By R. M. Fleming* 339

RICHARD FINSTERWALDER. **Geodätische, Topographische und Glaziologische Ergebnisse.** *By Frederick K. Morris* ..... 341

EMIL TRINKLER. **Geographische Forschungen im Westlichen Zentralasien und Karakorum-Himalaya.** *By Frederick K. Morris* ..... 342

HELLMUT DE TERRA. **Geologische Forschungen im Westlichen K'Un-Lun und Karakorum-Himalaya.** *By Frederick K. Morris* ..... 342

H. LAUTENSACH. **Portugal: Auf Grund eigener Reisen und der Literatur. Part I: Das Land als Ganzes.** *By Mark Jefferson* ..... 343

DIAMOND JENNESS. **The Indians of Canada.** *By Clark Wissler* ..... 345

FRANK LEVERETT. **Quaternary Geology of Minnesota and Parts of Adjacent States.** *By W. A. Johnston* ..... 346

HERBERT E. GREGORY AND RAYMOND C. MOORE. **The Kaiparowits Region: A Geographic and Geologic Reconnaissance of Parts of Utah and Arizona.** *By J. W. Hoover* ..... 347

RICHARD E. FULLER. **The Geomorphology and Volcanic Sequence of Steens Mountain in Southeastern Oregon.** *By M. A. Peacock* ..... 348

ERNST ANTEVS. **Alpine Zone of Mt. Washington Range.** *By Frank Leverett* ..... 349

ANDREW RUNNI ANDERSON. **Alexander's Gate, Gog and Magog, and the Inclosed Nations** ..... 350

EDWARD LUTHER STEVENSON, trans. and edit. **Geography of Claudius Ptolemy** .. 351

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# THE GEOGRAPHICAL REVIEW

VOL. XXIII APRIL, 1933 NO. 2


## THE FLIGHT TO MARIE BYRD LAND


Rear Admiral Richard E. Byrd


### WITH A DESCRIPTION OF THE MAP


Commander Harold E. Saunders


[With separate map, Pl. II, facing p. 208]

### Part I—The Flight

EVER since the decision had been made to go to Antarctica I had cherished the plan of a flight to the eastward from the Bay of Whales. The flight to the South Pole would, of course, be more spectacular, but my greatest interest lay in flying over into that hitherto unpenetrated area to the northeast of the Alexandra Mountains in King Edward VII Land. For decades ship after ship had endeavored to reach this region only to be turned back by impenetrable barriers of pack ice. This, too, proved to be the case with our attempts by sea in the fall of the first year, when each time the *City of New York* was turned back by adverse weather conditions.[1] Nor were our several attempts to fly there before the long winter night descended more successful. We realized that we should have to depend upon our meteorologists' forecasts for weather that would permit us to make the projected flight and accomplish definite results.

It was decided as a matter of principle not to attempt flights of exploration without clear enough weather to permit use of the camera. We schooled ourselves to patient waiting, and, thanks to the genius of our forecasters, we were not only spared the extreme hazards of flying in fog and snow but were favored on the South Polar flight and other exploratory flights by the conditions necessary for successful

[1] R. E. Byrd: Little America, New York, 1930, pp. 136–137, 144–145. For a general summary of the work of the Expedition see W. L. G. Joerg: The Work of the Byrd Antarctic Expedition 1928–1930, Amer. Geogr. Soc., 1930; also his "Brief History of Polar Exploration Since the Introduction of Flying," *Amer. Geogr. Soc. Special Publ. No. 11*, 1930, and edit., pp. 11–20.


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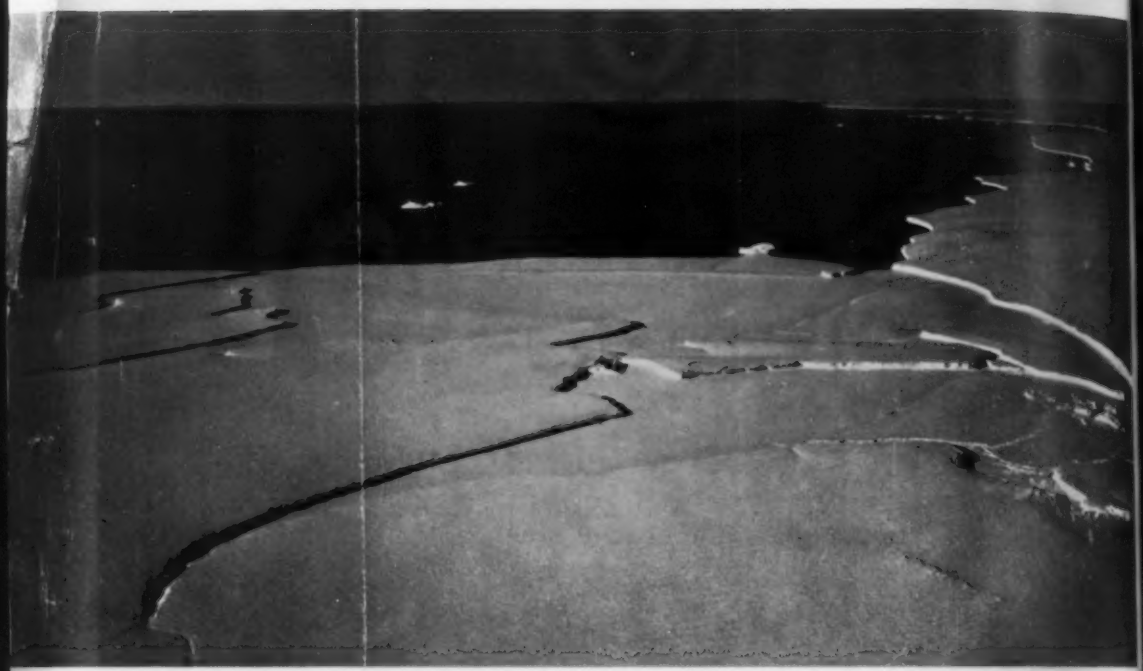

FIG. 1—Okuma Bay, looking north and northwest, with Cape Colbeck beyond the last point of shelf ice in the far distance at the right. (For the location of the photographs see Plate II, letters along the route: for Fig. 1 see T.)

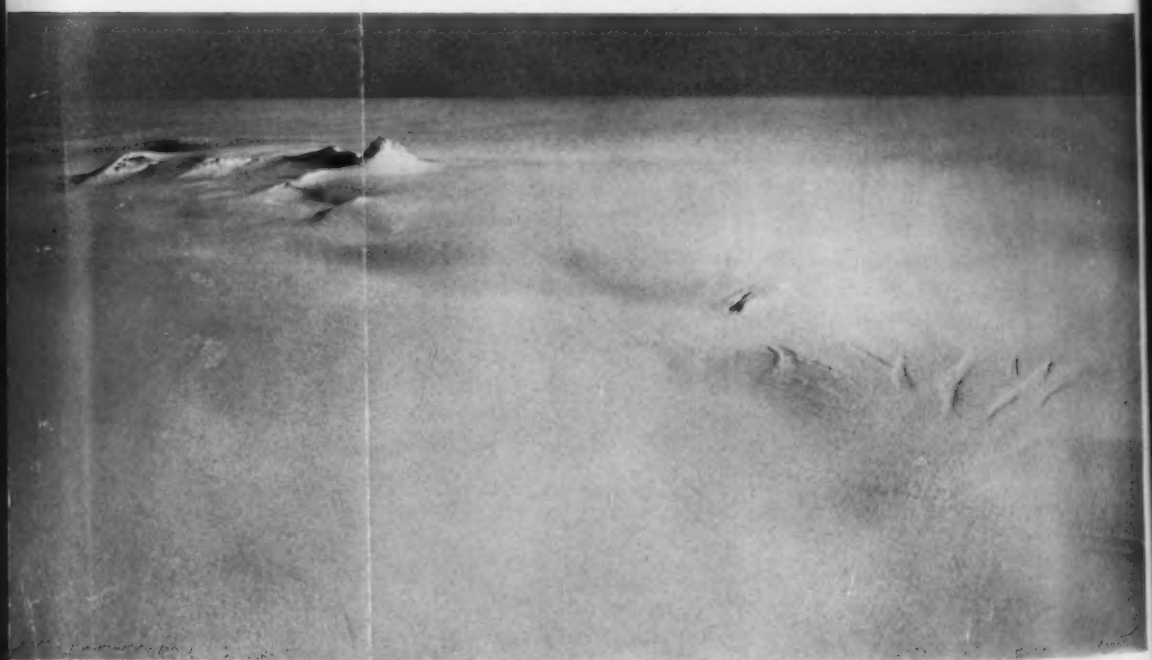

FIG. 2—La Gorce Mountain and a group of peaks in the southern part of the Alexandra Mountains. The widely separated snow-filled crevasses on the ridge at the right indicate slow ice movement. (S on Pl. II.)



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FIG. 3—The open lane of deep water near the head of Arthur Sulzberger Bay, looking north and northwest to the open water of the mouth of the bay and Ross Sea. (Q on Pl. II.)

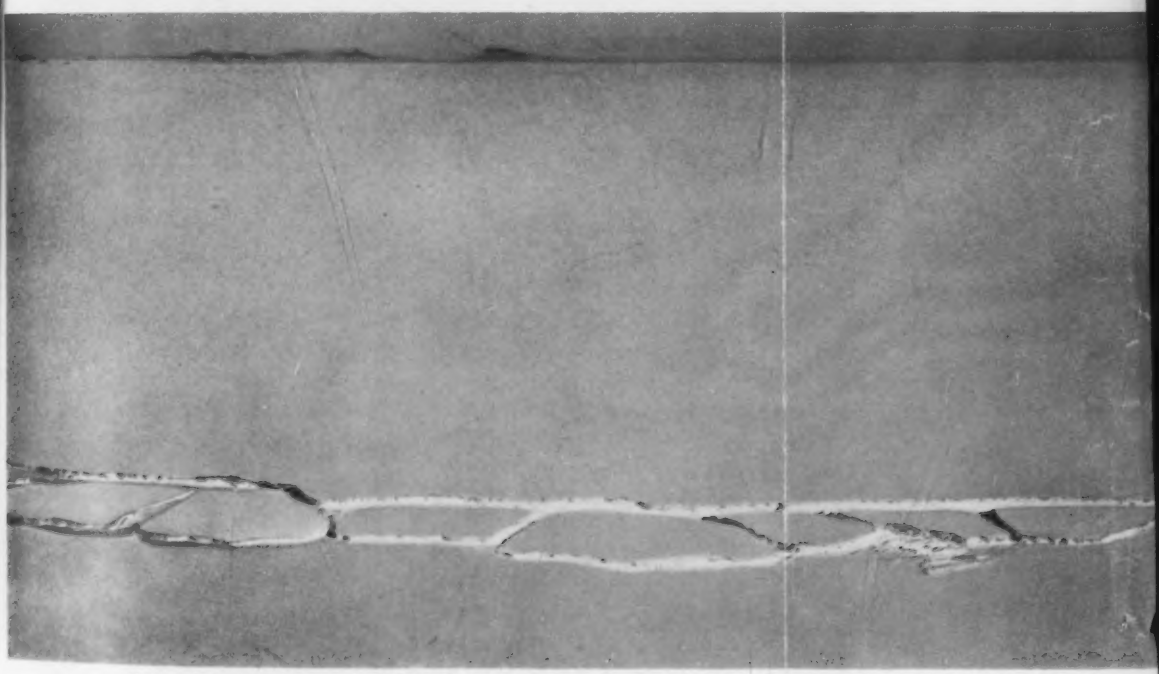

FIG. 4—The edge of the continental ice sheet at the western entrance to Paul Block Bay, breaking up into ice islands. In the background at the left, Hugh Mitchell Peak in front of Saunders Mountain. (I on Pl. II.)



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aerial photography. I believe it imperative that at least one efficient weather forecaster be included in the personnel of all polar expeditions. We carried two, William Haines and Henry Harrison, both of the U. S. Weather Bureau. Their services were of inestimable value; but even so, with the data to be collected, the services of a third meteorologist could have been employed to advantage.

On the morning of December 5, 1929, a week after the flight to the South Pole, Haines and Harrison made a series of balloon runs at Little America which showed slight southerly and southwesterly winds all the way up to 10,000 feet. These were the conditions that presaged good weather and clear atmosphere such as we had had on the polar flight. Haines gave the word to go, and at 10.50 a. m.[2] we took off in the trimotored airplane *Floyd Bennett*. Captain Alton Parker was at the wheel; his job was to steer a steady course for the series of photographs to be taken by Captain Ashley C. McKinley, our aerial surveyor.[3] Harold June's job was threefold as mechanic, radio operator, and relief pilot.

## The Course Set Northeastward

From Little America we flew out over the Ross Shelf Ice to the northeast and climbed to an altitude of 1900 feet. I laid a course that would take us about five miles north of Scott's Nunataks, twin peaks of the Alexandra Mountains first seen by the members of the British Antarctic Expedition of 1901–1904 from their ship, the *Discovery*, in Biscoe Bay. The wind had been southerly for several days preceding, and the Ross Sea to the north was clear of ice for the time being except for some scattered pack and a few icebergs in the distance.

We had observed regiment after regiment of ice fields drifting by the Bay of Whales, but, though the winds occasionally drove them into the bay, they generally drifted on westward. The number and the nature of these packs suggested that the vast unknown area to the northeast must be at least in part an archipelago, and we were on the lookout for islands ahead and seaward. As we approached Okuma Bay[4] there opened up to the north a wonderful range of snow-covered mountains. It was magnificent. Here indeed was a discovery! However, I had become cautious: that mountain range was too good to be true. And so it proved. On the return flight nothing of it was to be seen.

Okuma Bay was beneath us at about 11.40 a. m. We were then

[2] Local mean time of Little America for which 180th meridian time was used, taken as 12 hours slower than Greenwich time.

[3] Compare Captain A. C. McKinley's account of his work, "Mapping the Antarctic from the Air," *Natl. Geogr. Mag.*, Vol. 62, 1932, pp. 471–485.

[4] The name Hal Flood Bay proposed by the author was withdrawn when it was learned that the Japanese Antarctic Expedition had already given the name Okuma Bay to this feature. The bay was discovered by Scott on January 29, 1902. It was visited by the Japanese Antarctic Expedition on January 28-29, 1912.

at an altitude of 4300 feet, with a visibility of 80 miles or more. Our airplane was making over 100 miles an hour over the ground, the engines cruising at 1500 revolutions. With the wind nearly behind us, our drift angle was small. A little before noon we had the Rockefeller Mountains abeam. Although only about 40 miles away, the peaks of this group looked surprisingly low, and, as we watched, some of

FIG. 5—The Alexandra Mountains, looking southeast. The La Gorce Mountain group is hardly discernible in the center on the far horizon; at the left, with rock exposure, is John Bowman Peak. Scott's Nunataks are the prominent twin snow-covered peaks at the right, about five miles distant. The foot of the rock slope at the extreme left of the left-hand peak is the point from which Prestrud took his photograph ("The South Pole," Vol. 2, facing p. 258). (A on Pl. II.)

them passed from view behind imperceptible rises in the intervening ice sheet.

After we left Okuma Bay a good view was afforded of the area between the Rockefeller Mountains and the Alexandra Mountains. These looked like distinct groups, although the appearance of the undulating surface between them made it seem not improbable that they are joined by continuous land lying above sea level. Certainly there was no evidence of water under the ice between the mountains. We were now approaching Scott's Nunataks.

## SCOTT'S NUNATAKS

Lieutenant Prestrud, of Amundsen's party, and his companions had in 1911 made a sledge journey to King Edward VII Land.[5] They reached Scott's Nunataks but apparently could see only a very short distance beyond. We carried with us Prestrud's photograph of the nunataks and, comparing it with the bare rock surface at the northeastern corner of the eastern peak, were able to identify, without question, the very spot from which Prestrud took his photograph (compare Fig. 5).

The Japanese Antarctic Expedition also reached Scott's Nunataks.

[5] Roald Amundsen: The South Pole, London, 1913, Vol. 2, pp. 204–272.

On January 23, 1912, the expedition's ship the *Kainan Maru* was anchored in front of the Alexandra Range at a position given as latitude 76° 56′ S., longitude 155° 55′ W., but possibly somewhat nearer that suggested on Plate II.

From this position the range appears to have three peaks of which the one in the center is the highest, the eastern top being next in height. It was interesting

FIG. 6—Edge of the continental ice sheet in King Edward VII Land, looking northwest. In the distance is Biscoe Bay. The tongues in the ice sheet are breaking off in bergs, from half a mile to one and one-half miles across. The drifts around the ice edges indicate heavy snowfall. The thin shelf ice is breaking up in large areas with open-water cracks between. At the time of Prestrud's visit, December, 1911, open water extended practically to the tongues in the foreground if his estimate of distance was correct. (B on Pl. II.)

to note that at a height of about four-fifths the distance from the base to the top black markings were visible on each peak. The western peak was nearest to the ship and it was decided to land in order to examine the markings. . . . The distance to the ice barrier was about 2½ miles.[6]

The ship position given is almost 40 miles, in a straight line, from the assumed position of Scott's Nunataks. Elsewhere Shirase's report gives a ship position of latitude 77° 08′ S., longitude 154° 40′ W. This point is only about 18 miles from the peaks and rather far south for a ship to reach, although the remarkable photograph in Shirase's report of Scott's Nunataks was taken from his ship and at no great

[6] This and the following quotation are from the report of the Japanese Antarctic Expedition under Lieutenant Shirase, 1912, entitled "Nankyoku-ki," published under the auspices of the South Pole Exploring Association, by the Seiko-Zasshi-Sha, 468 pp., Tokyo, 1913; reference in Chap. 4, pp. 179–200 [in Japanese; translated by Hashime Murayama].

distance, for practically all the rock markings on McKinley's photographs can be identified on the photograph of Shirase. Two men of Shirase's Expedition climbed Scott's Nunataks.

For ten miles the going was uphill before they reached the foot of the snow-mountain at 6 a. m. on January 24th. They had left the ship *Kainan Maru* at 4.30 p. m. on the 23rd and thus had spent 14 hours traveling inland . . . On the

FIG. 7—Looking south into Arthur Sulzberger Bay. A wide fringe of sea ice bounds the open water in the bay. Just behind this fringe may be seen a thin white line marking the edge of the thin shelf ice in the bay. In the background, toward the southeast, is an open-water area in the shelf ice near the head of the bay. (D on Pl. II.)

side of the mountain they could clearly see the black spot where the bare rock jutted forth. They started for the bare spot, but had great difficulties in climbing the steep mountain side. They found large cracks in the ice . . . about 70 feet from the bare rock . . . they erected a post with an inscription. From this distance the rock appeared to be of granite and its upper part showed a gray color with red spots . . . On their return trip they found some high hills which they climbed, and from which they had a good view of the surrounding landscape. From here they could see the middle mountain send out a range about 1,000 feet high towards south-southeast for about 20 miles. The end of the range was hidden from view in clouds. They believed that if one followed this chain one would reach the South Pole . . . The Alexandra Mountains [i.e. Scott's Nunataks] were measured from the boat, and showed that the highest peak was about 1,600 feet above sea level. Soundings proved the place of anchorage to be about 140 fathoms deep, and the bottom was covered with gray-colored mud.

## OTHER PEAKS OF THE ALEXANDRA MOUNTAINS

At 12.27 p. m. we passed Scott's Nunataks five miles distant on the starboard beam, having climbed in the meantime to an altitude

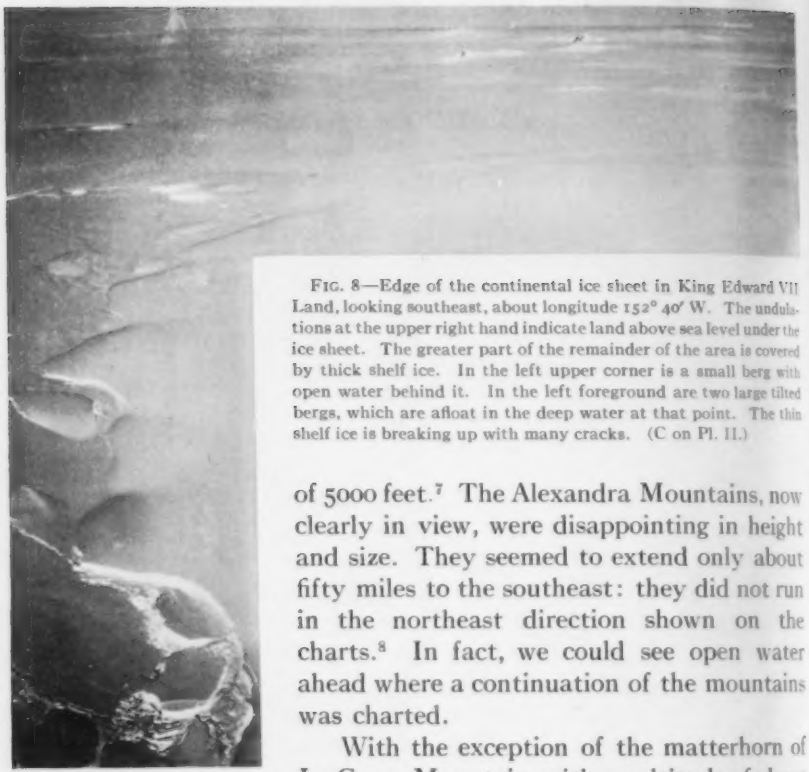

FIG. 8—Edge of the continental ice sheet in King Edward VII Land, looking southeast, about longitude 152° 40′ W. The undulations at the upper right hand indicate land above sea level under the ice sheet. The greater part of the remainder of the area is covered by thick shelf ice. In the left upper corner is a small berg with open water behind it. In the left foreground are two large tilted bergs, which are afloat in the deep water at that point. The thin shelf ice is breaking up with many cracks. (C on Pl. II.)

of 5000 feet.[7] The Alexandra Mountains, now clearly in view, were disappointing in height and size. They seemed to extend only about fifty miles to the southeast: they did not run in the northeast direction shown on the charts.[8] In fact, we could see open water ahead where a continuation of the mountains was charted.

With the exception of the matterhorn of La Gorce Mountain, with an altitude of about 2700 feet, the Alexandra Mountains consist of a group of snow-covered peaks only about 1500 feet high, rising from an irregular and uneven ice sheet, indicative of a rolling topography underneath.

Close by our line of flight to the north the continental ice sheet was broken here and there by heavily crevassed areas where the land fell steeply away from the Alexandra Mountains toward Cape Colbeck. Under the enormous pressure caused by this flowing ice the heavy sheet along the shore of the bay had buckled into huge rolls—long rounded ridges with valleys between. The ice breaking away in these valleys developed an unusual formation of tongues sticking out into the thinner shelf ice to seaward. The cliffs bounding the tongues must have been 200 or 300 feet high in places. Icebergs had broken off and, except where grounded, were pushing their way through the shelf ice toward the open sea.

The band of shelf ice lying offshore, around the ice tongues, merged

[7] Drawings of these and adjacent peaks are to be found in R. F. Scott: Voyage of the *Discovery*, London, 1905. Vol. I, facing p. 190, and in National Antarctic Expedition, 1901–1904; Geology, Vol. I, London, 1907, p. 24. Both these examples show a vertical-walled barrier, quite high, in front of the mountains.

[8] British Admiralty Chart No. 3206, sheet VIII, Antarctic Regions, shows the Alexandra Mountains running northeastward to latitude 76° S., longitude 150° W.

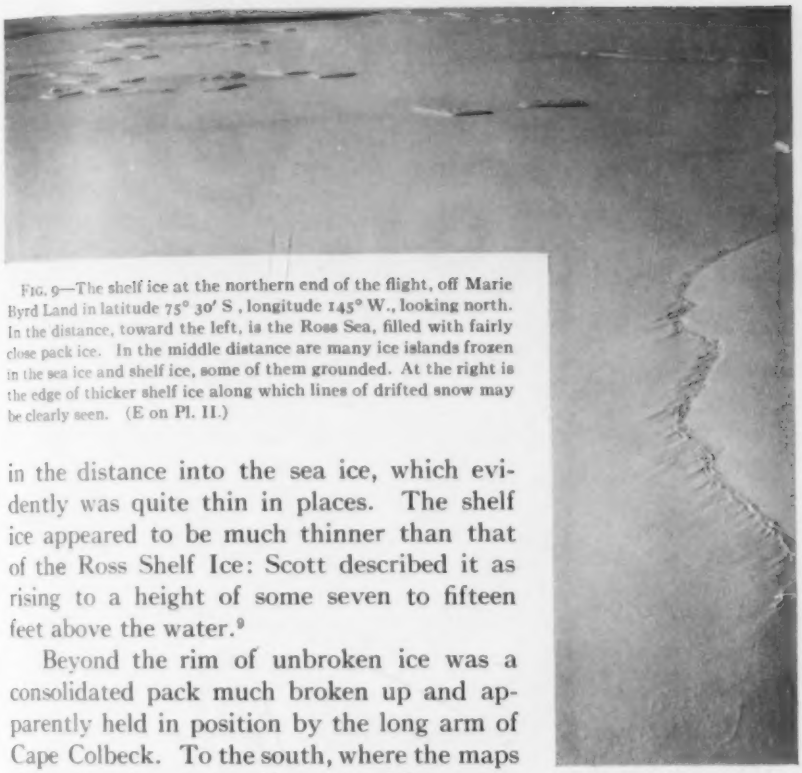

FIG. 9—The shelf ice at the northern end of the flight, off Marie Byrd Land in latitude 75° 30′ S., longitude 145° W., looking north. In the distance, toward the left, is the Ross Sea, filled with fairly close pack ice. In the middle distance are many ice islands frozen in the sea ice and shelf ice, some of them grounded. At the right is the edge of thicker shelf ice along which lines of drifted snow may be clearly seen. (E on Pl. II.)

in the distance into the sea ice, which evidently was quite thin in places. The shelf ice appeared to be much thinner than that of the Ross Shelf Ice: Scott described it as rising to a height of some seven to fifteen feet above the water.[9]

Beyond the rim of unbroken ice was a consolidated pack much broken up and apparently held in position by the long arm of Cape Colbeck. To the south, where the maps showed peaks of the Alexandra Mountains, lay a wide sweep of open water. From Biscoe Bay it extended far to the southeast. This was later named Arthur Sulzberger Bay. The direction and contour of the ice edge and coast line were quite different from what we had been led to expect.

As we moved out and away from the coast line on the northeastern shore of King Edward VII Land, we could see almost at a glance all the stages in the ice formation between the high continental ice sheet and the open water of the bay under us. Sliding down the undulating surface of the hills in the Alexandra Mountains, the land ice terminated in a barrier-like formation with white cliffs from 200 to 250 feet high. Beyond these cliffs, in a fringe of shelf ice of a thickness intermediate between the old bay ice and the land ice, lay large ice islands with rounded domes,[10] which had broken away from the sheet and were slowly making their way toward the sea. The shelf ice was fringed with old bay ice, and the latter again with young sea ice, the whole forming a belt from 10 to 20 miles in width.

[9] Scott, *op. cit.*, Vol. 1, p. 183.

[10] Prestrud found similar ice islands in the southwest corner of the Bay of Whales in January, 1912 (Amundsen, *op. cit.*, Vol. 2, pp. 265–266). See also Scott, *op. cit.*, Vol. 1, pp. 180–181 and F. Debenham: Report on the Maps and Surveys, British (Terra Nova) Antarctic Expedition, 1910–1913, London, 1923; reference on pp. 56–57.

FIG. 10—The northern end of the Edsel Ford Range in Marie Byrd Land. The long line of high, rocky peaks to the right is the Raymond Fosdick Mountains. The ridge on the left, covered with snow on its left side and showing rock on its right side, is Mt. Harold June; Bernt Balchen Glacier lies between it and the Raymond Fosdick Mountains. The high plateau may be seen behind Mt. Avers, at the extreme right. (F on Pl. II.)

## DISCOVERY OF THE EDSEL FORD RANGE

With the Alexandra Mountains drawing astern, we could now look into the great blank spaces of the chart. At about 12.40 p. m., flying on a course about N 57° E, we saw ahead and slightly on our starboard bow what appeared to be a mountain mass. In a few minutes appearance became certainty; more peaks loomed up, and there was a suggestion of a long range lying well to the right of our course. This was indeed a discovery. On our starboard bow lay the great ice-covered expanse of Arthur Sulzberger Bay running for miles to the southeast, but there appeared to be ice-covered land between the Alexandra Mountains and the newly discovered range. Ahead was a great dark area of open water; in its eastern end floated a gigantic floe at least a dozen miles long. To save valuable flying time we took the risk of flying directly across the thirty miles of open water.

The mountains ahead were quite far off. We had a visibility of more than 100 miles, and apparently they were at least as far distant as that when we first sighted them. These new mountains we named the Edsel Ford Range.

At about 1.00 p. m. we passed the 150th meridian, the eastern boundary of the British claims in the Ross Dependency. The land ahead we could claim for the United States without dispute, since it had not before been seen by man.

## THE CONTINENTAL SHORE LINE IN MARIE BYRD LAND

We continued on a course of N 57° E until we could see ahead and to our right the high, white, unmistakable cliffs of the shelf ice having somewhat the appearance of a shore line. A radio previously received from Dr. Isaiah Bowman suggesting a flight to the northeast had mentioned the great importance of attempting to include the line of the seacoast in the photographs. To hold the line of the

FIG. 11—This view of the Edsel Ford Range is taken a little southwest of Figure 10 with which it virtually forms a panorama. To the left is the western end of the Raymond Fosdick Mountains; in the center is snow-covered Mt. Iphigene; between is Adolph Ochs Glacier with the peak Marujupu standing in its center. To the right of the photograph, at the edge of the ice sheet, are the Birchall Peaks; behind them is Saunders Mountain, and to the extreme right and farther away is Mt. Rea. (G on Pl. II.)

barrier ahead within the field of view of the camera, we turned left at 1.13 p. m., taking a course first N 13° E and then about N 35° E.

Unable to tell exactly where the continental ice sheet ended we decided to keep well to seaward—far enough so that it must lie somewhere between the plane and the mountains. As will be seen from the map, Plate II, our course was more or less parallel to the high ice cliffs which probably lay over or near this coast line.

Even for explorers traveling by dog team in this particular area it would probably be impossible to tell exactly where the shelf ice ended and the land began, so thoroughly is it covered, landward and seaward, with snow and ice. What we took to be and still think is the edge of the continental ice sheet might very well be thick shelf-like ice and snow grounded in water of varying depths.

It was evident that icebergs had also been periodically breaking off the continental ice sheet on this side of the bay. There appeared to be deep enough water at the edge for them to plow their way slowly through the shelf ice; but farther seaward, at different distances, some of the bergs were grounded. Once aground the bergs would become broken up into many blocks, checkerboard fashion, by huge crevasses crisscrossing their entire upper surface. Some of the bergs must have been grounded for a considerable time, as the crevasses were well filled with snow. Beneath us, here and there, were clouds, whose deceptive shadows gave at times the appearance of crevassed areas when seen in the distance or thin ice when seen close aboard under the airplane.

Between the line of the ice cliffs that we were paralleling and the Edsel Ford Range was a relatively flat area 80 or 90 miles in width, which narrowed somewhat as we proceeded northward. A solitary pyramidal peak rose about 25 miles inland from the ice cliffs; hence land presumably extends to some point between this peak and the ice edge. We passed more and more bergs which had apparently just broken off the thick ice sheet and were forcing their way through

the shelf ice to seaward. We assumed, and I think rightly so, that the ice was afloat along the line of cliffs where it was breaking up.

Our altitude was now about 4600 feet. New vistas were opening up in the mountain range to the east. To the west and north spread many miles of ice dotted with bergs of all sizes and shapes. Beyond lay an ice-strewn waste of open water, stretching limitless to the

FIG. 12—The boundary of the ice sheet west of the mouth of Paul Block Bay. In the middle distance, running diagonally across the photograph from upper left towards lower right, is a dark area showing ridges and undulations in the continental ice, marking higher land behind the west shore of the bay. Hugh Mitchell Peak is in the distance, at the center. (H on Pl. II.)

horizon. At 1.48 p. m. we changed course to the east to get nearer the mountains. On our port beam, to the north, was open water not much more than 20 miles away. The whole area under us was still strewn with ice islands. It was impossible to tell how many were afloat and how many aground.

## GLACIERS AND BERGS

We were now flying parallel to a range of high, rugged mountains that branched off to the east at an angle from the main range. There came into view on the starboard bow a superb glacier, blue between two gray-black walls. In the center of the ice stream stood a high black peak. The peak I named Marujupu: the glacier I named after my friend and benefactor, Adolph Ochs.[11]

At 2.10 p. m. we turned southward. Ten minutes later we changed

[11] Byrd, *op. cit.*, photograph facing p. 368 and Figure 11 above. The names proposed for new features are derived for the most part from the names of benefactors of the expedition and from its personnel. Marujupu combines letters from the names of four grandchildren of Mr. Adolph Ochs.

course again to obtain photographs at closer range of the cliffs, 120 feet high, along the edge of the ice sheet, which we paralleled for about 30 miles. We observed and photographed the breaking off of giant bergs and ice islands and their manner of drifting away through a sea covered with thick and apparently solid ice (Fig. 4).

FIG. 13

FIG. 14

FIG. 13—The edge of the continental ice sheet at the western entrance to Paul Block Bay. The breaking up of the sheet appears to be fairly rapid, notwithstanding the fairly heavy shelf ice lying offshore and around the bergs. In the foreground is an ice island drifted up with snow. (J on Pl. II.)

FIG. 14—An ice island in the eastern part of the Ross Sea in latitude 76° 30′ S. The crevasses are very old and filled with snow. The island lies at the intersection of the thin shelf ice (upper left) and sea ice (lower right). It has been split into three pieces by movements in the shelf ice. (L on Pl. II.)

The breaking off of the bergs at the edge of the heavy shelf ice must largely be governed by local conditions, for quite frequently the fractures do not occur along lines of crevasses previously formed in the ice. That the crevasses must be very old to have become entirely filled by snow or cemented by fresh ice below the water line seems likely from previous evidence;[12] it may be that the rate of movement of the ice sheet is rather slow.

From our position in about latitude 76° S. and longitude 148° W. the Edsel Ford Range appeared to run generally north and south, the northern end tapering off to low, snow-covered ridges whose sides presented bright spots here and there against the sun. To the

[12] T. W. Edgeworth David and R. E. Priestley: Geology (Sci. Results British Antarctic Expedition, 1907-9), Vol. 1, London, 1914, p. 36.

south the range seemed to be broken up into more or less isolated mountain groups rising boldly from the low, irregular foothills surrounding them. The range was split at its northern end by Bernt Balchen Glacier, a wide stream of ice flowing westward at the foot of the high and almost unbroken cliffs of the Raymond Fosdick

FIG. 15—Open water areas in Arthur Sulzberger Bay, looking northeast from latitude 76° 55′ S., longitude 150° W. The larger area in the right foreground has been formed by bergs broken from the continental ice sheet (the tip of which can just be seen at the right) and drifting away. The thin sea ice thus broken up is drifted by the wind along to the leeward side of the area. In the right background, about 30 miles distant, is another and much larger open-water lane alongside the edge of the thick shelf ice. (M on Pl. II.)

Mountains and joined at the western end by the Adolph Ochs Glacier.

The joint glacier flows into a low region of shelf ice which, by reason of its relatively level surface with respect to the surrounding ice, leads one to believe that it may be afloat. It spreads into an ever widening stream as it moves slowly to the northwest, bounded on each side by irregular white cliffs which, in one point particularly, show the telltale crevasses indicative of land underneath. The mouth of the bay is filled with a great fanlike delta of moderately thick shelf ice, forcing its way slowly into the surrounding sea ice. In common with other ice tongues in parts of the Antarctic it may be partially aground on a submarine moraine left by a huge glacier of former days.

Looking up Adolph Ochs Glacier and across the tops of the nearer peaks, we saw what we thought to be an immense high plateau, dotted here and there with outcropping ridges of rock. There are, beyond

doubt, glaciers running out westward from this plateau, but we were too far away to distinguish them clearly. The mountains of the Edsel Ford Range may be from 4000 to 5000 feet high, though, because of their distance from the airplane and the unknown height of the land from which they rise, this is a very rough estimate. Among the more

FIG. 16—The unique open-water lane at the head of Arthur Sulzberger Bay, in latitude 77° 23′ S., longitude 149° 30′ W., looking northwest. This area is about 4 miles long by half a mile or more in width. Compare Figure 3, a continuation of this area to the northwest. (P on Pl. II.)

striking peaks are Hugh Mitchell to the northwest, a solitary, almost perfect pyramid emerging from the seemingly level and unbroken snow plain 15 miles from the nearest sign of rock or land, and Mt. Grace McKinley, a more massive outpost in the south, at least 35 miles from the nearest group of mountains visible on our flight.

## APPEARANCE OF ISLANDS IN THE ROSS SEA

We were now flying westward toward the region in which Scott, in the *Discovery*, had been turned back in February, 1902. There was now, as there had been on our outward journey, an appearance of ice-covered land islands toward the northwest. We continued westward toward the open sea for some distance and then turned north. After flying on this course for about 15 miles it became clear that the islands, if islands they were, lay too far away for us to reach them and complete the other investigations planned. They were too distant to be photographed and may have been only a mirage.

## Lanes of Open Water in Solid Ice Fields

We headed southward again at about 3.10 p. m., and directed our course so as to fly close to a large and interesting grounded ice island on the port hand (Fig. 24). We passed it abeam at 3.15 and continued on southward to investigate certain lanes of open water miles within the edge of the shelf ice sighted on the outward flight.

As we approached the foot of Arthur Sulzberger Bay the view of

Fig. 17—The edge of the land on the east shore of Arthur Sulzberger Bay in latitude 77° 18′ S. The crevassed area indicates steep cliffs The well defined ridge at the lower ice level parallel to the cliffs and somewhat to the right of them is due to buckling from lateral pressure caused by the ice sliding down the cliffs. (O on Pl. II.)

the Edsel Ford Range to the east steadily enlarged. Against the horizon a series of irregular and isolated groups of steel-gray or snow-covered mountains extended south as far as the eye could see. The northernmost peak was at least 100 miles away, but at our altitude of 4400 feet it was still distinctly visible.

Shifting our course a little to the east of south, we headed toward the open water seen farthest to the south on our outward flight across the bay. Its weird appearance is illustrated in Figures 3 and 16. The open water, perhaps four miles from end to end, lay in a narrow arm of the bay between moderately high land on each side. Along the southern shore the land ice lay over rock cliffs and was heavily crevassed in spots. Along the northern shore the tongues were obviously the remnants of a series of long wrinkles or undulations in the shelf ice, the result of buckling under the influence of pressure from the land ice behind.

Just why these open-water lanes should defy freezing we do not yet understand. It may be that strong currents help to keep them open. It is possible also, that, as pointed out by David and Priestley,[13] there is a thawing effect due to currents of warmer water from underneath. I venture the opinion, however, that these areas are regions

[13] David and Priestley, *op. cit.*, Vol. 1, pp. 13 and 137–138.

of deep water where the ice sheet, advancing from the land or from shoal water, slides off into the sea and breaks up. The bergs thus formed float clear and drift away under the influence of wind and current, carrying with them the thin sea ice that forms on the deep water area in relatively calm and cold periods.

If the aerial photographs of these three or four water lanes be examined closely, there will be found to the north or to the west of

FIG. 18—A broad view of the Alexandra Mountains and King Edward VII Land, looking to the southwest. Just beyond the undulating foreshore of the continental ice sheet at the left is a long lane of open water indicating the deep channel in Arthur Sulzberger Bay. To the left, in the far distance, is the La Gorce Mountain group. (N on Pl. II.)

each area a jumbled mass of bergs and pack ice, unquestionably driven there by southerly or southeasterly blizzards. The floating bergs, propelled by the high wind, have broken up the thin sea ice and swept the greater part of it along with them. The loose floes and pieces remaining have been blown out by the wind, leaving a clear body of open water behind (Fig. 15).

## LA GORCE MOUNTAIN GROUP

At 4.25 p. m. we headed toward the west for a closer view of La Gorce Mountain. About 7 miles beyond the lane of open water we flew over an area of wide, deep crevasses, resembling those encountered by Amundsen and by our own sledging parties at 81° S. on their trips south from the Bay of Whales. The underlying land must at this point drop sharply to the northeast. Looking back from the Alexandra Mountains to Mt. Grace McKinley, now low on the horizon to the southeast, the whole ice surface appeared undulating and irregular, not at all suggestive of water underneath.

The matterhorn of La Gorce Mountain is a majestic, gleaming peak, thrusting its sharp head high above a consolidated group of lesser peaks flanking it on its southeastern side. It is a landmark not only by its relative height but because it is the only peak in the

whole Alexandra Mountains whose summit is not covered by the ice sheet.

The ridge of which the La Gorce Mountain group forms the principal part parallels at a distance of 10 or 15 miles the line of peaks to the northeast that terminate in Scott's Nunataks. It appears to drop off rather sharply to the northeast throughout the greater part of its length. In fact, the most precipitous cliffs of all the visible peaks in King Edward VII Land lie on their northeastern sides.

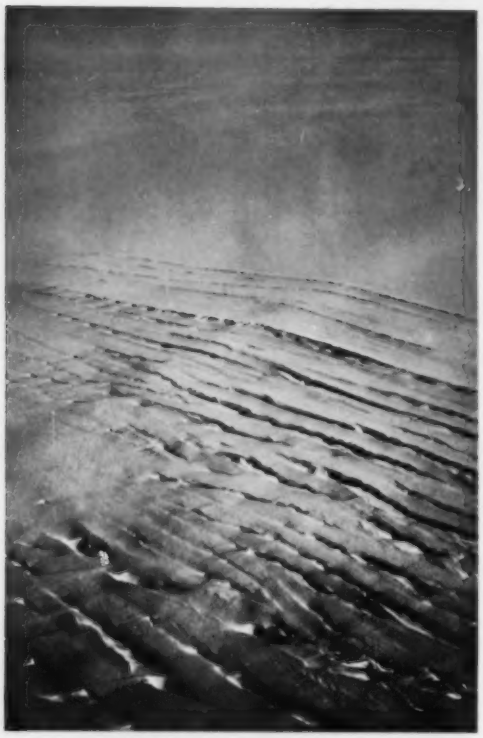

FIG. 19—A heavily crevassed area on a steep slope in the extreme west of Marie Byrd Land. The largest crevasses are from 200 to 300 feet wide. Some crevasses have been filled and others are filling with snow. (R on Pl. II.)

We changed course at 4.55 p. m. to the northwest and headed back towards the coast to have another look seaward, flying over and around other peaks of the Alexandra Mountains, now viewed and photographed from four sides. There were few, if any, evidences in the group of the fierce winds encountered by Gould and his party in the Rockefeller Mountains,[14] winds that swirled and scoured great valleys around exposed peaks and filled up the leeward sides of the hills with great sloping drifts. Whether this is due to the relatively greater ice movement in the Alexandra Mountains, to the greater snowfall, or to a difference in the winds themselves, I do not venture to say.

At 5.05 we changed course to the west, then later to the southwest, taking a long series of photographs of the Rockefeller Mountains group as we circled slowly around them.

## RETURN TO LITTLE AMERICA

By 5.42 we had reached Okuma Bay, still holding an altitude of about 5000 feet; at this time there was no such appearance of mountains to the northward as we had seen on the outward journey. Back

[14] Laurence M. Gould: Some Geographical Results of the Byrd Antarctic Expedition, *Geogr. Rev.*, Vol. 21, 1931, pp. 177–200.

at the coast line and retracing our course, we dropped to an altitude of about 1400 feet, speeded up the engines, and covered the last miles of our flight uneventfully, landing at Little America at 6.42. We had been in the air for nearly 8 hours and had covered 832 miles.

### Results of the Flight

From a geographical standpoint the flight was eminently successful. It developed the details of King Edward VII Land, extended the outline of the coast beyond by 200 miles, and filled in a great section of the map that had hitherto been blank. It proved the existence of new land to the northeast and revealed a great mountain range—discoveries claimed in the name of the United States of America. However, discovery is only the beginning. The flight is a reconnaissance from which survey flights and possibly sledge journeys may be planned for the acquisition of detailed knowledge as opportunity affords.

On the return of the expedition to the United States, where full facilities were available for the analysis of the photographs, we set to work to reconstruct the northeastern flight and to prepare a map that should embody all the information obtained from the aerial photographs. This map is included as Plate II. Its construction, which is described by him in the following pages, was carried out by Commander Saunders, Construction Corps, United States Navy. It had been my intention to sail with the *City of New York*, prior to this flight, northeastward as far as practicable, for sounding, coastal exploration, and accurate position fixing for map making. But unfortunately the ice in Ross Sea was too thick for the *Eleanor Bolling* to get through to Little America with coal, and the *City of New York* reached there barely in time to get us out before the freeze up. The result was that Commander Saunders had to contend with the great handicaps of insufficient ground control and lack of determinations of position along the flight track. His successful handling of the material under these circumstances is nothing short of remarkable.

## Part II—The Map

The map (Pl. II) may be considered a preliminary reconnaissance survey. It is intended to show the extent and general nature of the country and to indicate the location and relative position of the principal landmarks accurately enough to permit of finding one's way on subsequent flights or to enable the planning of systematic surveys and the establishment of suitable ground control stations.

The problem of making a map from a series of photographs taken at altitudes not accurately known, depicting a terrain composed of hills and mountains of unknown elevations, and regulated by ground

control points that were conspicuous by their almost complete absence, seemed at first well-nigh hopeless. It was soon obvious that no great degree of reliability could be expected by following any single process or method. However, when two or more methods, applied judiciously in turn, were found to produce consistent results, a reasonable degree of certainty could be admitted. Thorough analysis of this kind means hard and long-continued work, which, however, may be somewhat lessened by the use of certain procedure and devices that will be described. Among these the orientation of photographs by means of shadows greatly facilitates the solution of the problem; and it is believed that an explanation of this method will be of particular interest, for, as far as is known, it has not been used or described before.

## Identification of Points

In work of this sort much depends upon the care taken in that most innocent-looking operation, the identification of landmarks; and it is surprising to find that repeated examination of aerial photographs, after all possible sources of information have apparently been extracted, continues to produce further evidence of value. Survey and exploration flights are frequently made in the forms of loops, in which the airplane doubles back on its own course, roughly speaking, and in which photographs are taken on both outward and inward legs of the journey. Between photographs of the same objects, going and coming back, the sun will have changed position so as to produce different shadow effects, and the airplane may be just far enough from its original course to cause outstanding landmarks on the first part of the flight to assume the appearance of entirely strange objects when viewed again. Reliable identification under these circumstances may require hours and even days of patient study. It can frequently only be checked by agreement of the observed positions of these objects with positions calculated or determined from plots of other more definite landmarks. For example, Donald Woodward Mountain in the Edsel Ford Range of Marie Byrd Land loomed up on the outward journey as a large mountain mass, quite separate from the other mountains in the range and easily identified. It was only after much laborious plotting that a small distant peak, seen low on the horizon from the northern end of the range, in the midst of many other mountains, much later in the flight, was identified as the top of the same mountain.

## Methods of Plotting Employed

In constructing the map of the area covered by the northeastern flight considerable use of the Canadian grid method was possible, since Byrd was particular to keep the shelf ice shore in the foreground during most of the flight, especially beyond Scott's Nunataks (Fig. 20).

On the other hand, certain photographs, such as those of the new mountains in Marie Byrd Land, were characterized by a complete absence of ground control points, a lack of anything approaching a level plane, only approximate estimates as to mountain heights, and only information of a general nature as to the direction in which the

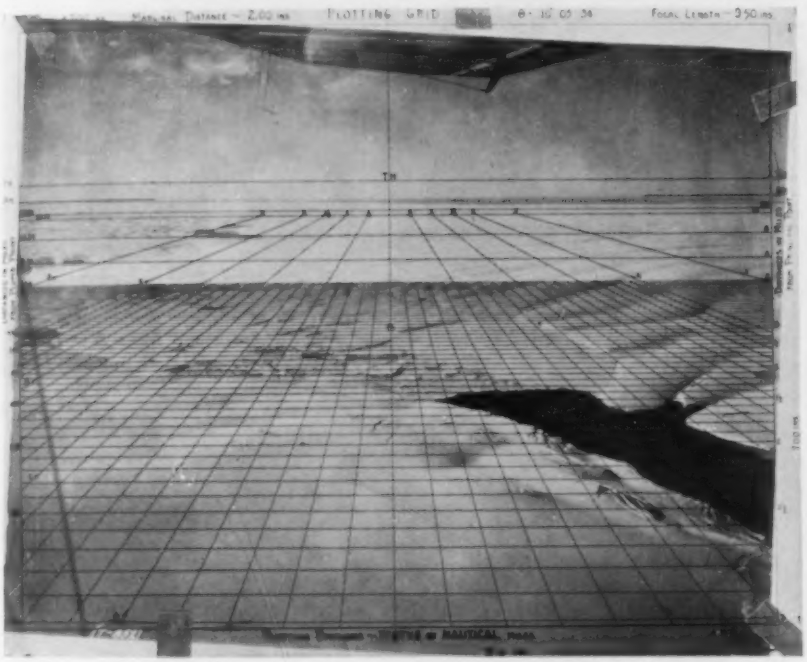


FIG. 20—Plotting grid applied to an oblique aerial photograph (Arthur Sulzberger Bay).

camera was pointed when the individual photographs were taken. In these cases the use of the Canadian method was of little avail; and by far the greater portion of the reconnaissance map, therefore, was constructed by the use of bearing plots, involving a familiar form of graphical resection and intersection combined with navigational control from the dead reckoning.

Now, whatever else may be indeterminate about the positions of objects imaged in a photograph, it may be determined with reasonable accuracy that they lie in vertical planes radiating from the plumb point of the camera station at definite angles with each other, provided the focal length of the camera and the approximate tilt of its axis are known. Consequently by a process of trial and error individual sets of bearings were made to fit together, which, combined with what little was definitely known as to geographical positions of some of the identified points, airplane speeds, and the like, ultimately gave a correct picture of the relative positions of camera stations and points in the terrain.

## Plotting of Bearings

The device used for extracting the horizontal angles between the selected points or landmarks in a photograph is called a "bearing grid." This, as shown in Figure 21, is placed over a photograph and

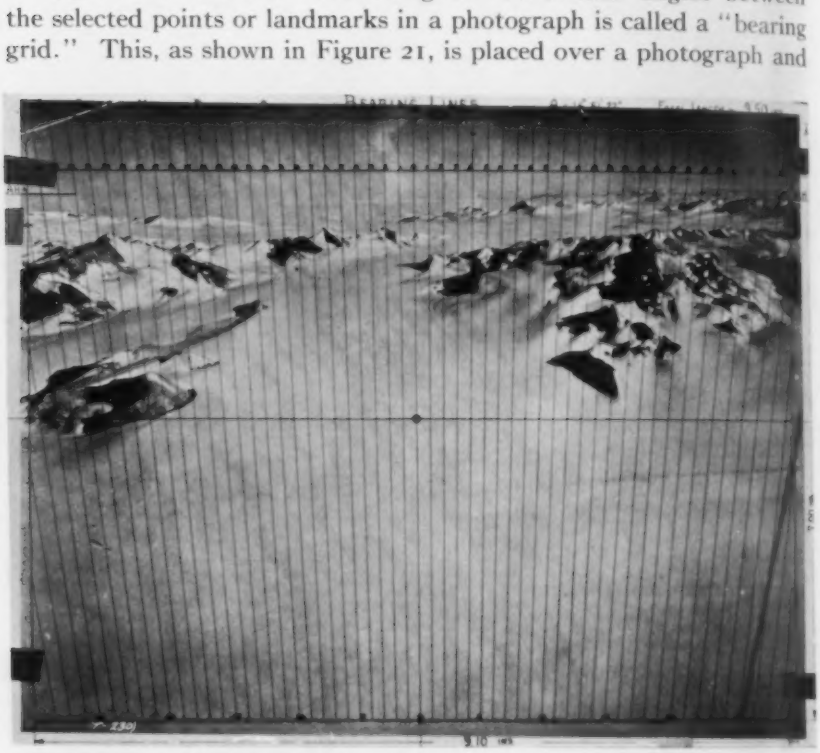

Fig. 21—Bearing grid applied to an oblique aerial photograph. The bearing angles are marked in degrees on a scale across the trace of the true horizon.

consists of lines at given integral angles (degrees), all radiating from the plumb point.[15]

With these divisions, there are so many lines on the grid that it has to be lifted frequently to make sure of the identification of landmarks and to check the position of objects lying almost directly underneath the lines, but with practice it is possible to estimate by eye to the nearest tenth of a degree. Assuming the grid were graduated in tenths of a degree or less, only rarely would landmarks stand out so definitely as to permit reading accurately to this amount.

To draw the bearing lines thus obtained a celluloid sheet (used film with the emulsion removed is excellent) is placed over a paper protractor which has been prepared for the purpose, as illustrated in Figure 22; a pin is pushed through the film to the center of the pro-

[15] A grid of this kind, or "graticule," as it has been sometimes called, was first described by B. M. Jones and J. C. Griffiths: Aerial Surveying by Rapid Methods, Cambridge (England), 1925, who supplemented it by lines representing equal depression angles below the horizontal plane through the camera lens.

tractor, serving as a mark for the airplane position and as a guide to the straightedge; and the bearings of the various landmarks are drawn in at the proper angles, as given by the tabulated bearing data sheet.

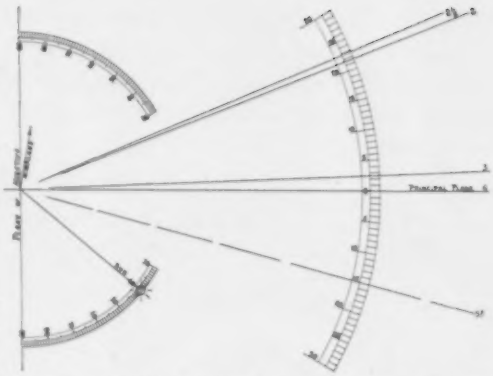

FIG. 22—Method of constructing bearing plot over bearing protractor. The arcs are on the protractor and the remaining lines on the transparent celluloid bearing plot.

These bearing plots were made for aerial photographs taken at intervals along the airplane course of about one-tenth the distance to the nearest landmarks being observed. If the course was changed or new landmarks appeared additional plots were made. A little experience with each case indicated the number of plots necessary, and the photographs that showed the greatest number of objects in common with those previously selected were always chosen. For the northeastern flight, of which some 645 miles were covered by 248 aerial photographs, a total of 124 bearing plots were made.

## MULTIPLE-ARM PROTRACTOR FOR PLOTTING

A multiple-arm protractor was devised to provide a ready means of resecting the airplane position when the bearing angles from certain already fixed landmarks had been determined. It consists essentially, as Figure 23 shows, of a large but light circular frame about 17 inches in diameter, graduated in degrees for a range of 30° each side of the assumed position of the principal plane.

Mounted on slides on this ring are eight sectors of celluloid, so arranged that both sides of each sector lie along radial lines from the center of the ring. The sectors may be moved to any desired position and clamped. Each sector of the design illustrated occupies 8° of arc.

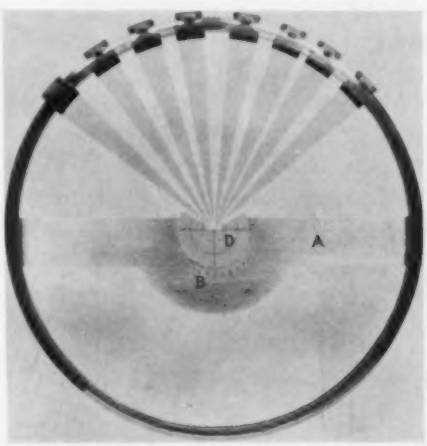


FIG. 23—Multiple arm protractor for solving groups of multiple bearing angles. The eight arms may be set in any desired positions.

Numbered buttons (not

shown in the photograph) are slipped over the screws adjacent to the edges of the sectors that are set to the bearing angles corresponding to the numbered landmarks. This is necessary to avoid confusion when three or more points on the protractor are being adjusted simultaneously.

An aluminum plate, *A*, extending across a diameter perpendicular

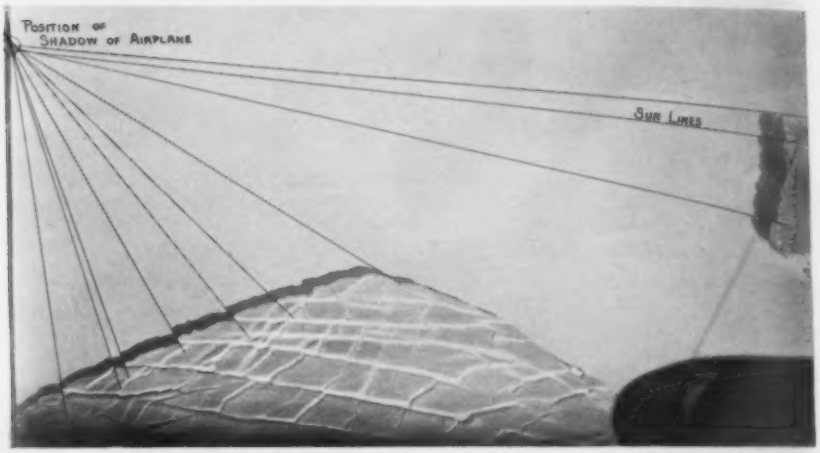


FIG. 24—Intersection of projected sun lines from shadows on an aerial photograph. Ice islands in Ross Sea in latitude 76° S. as viewed from the westward. (K on Pl. II).

to the principal plane, carries in a recess in the center a movable celluloid disk, *D*, cut away on one side to represent the plane of the negative and having scribed upon it a line representing the principal plane of the camera. The disk turns freely in the recess so that the cut-away side may be used also to draw in the airplane axis. A convenient scale, *B*, permits setting the disk at an angle corresponding to the known (or estimated) angle between the negative and the fore-and-aft axis of the airplane.

Concentric lines are scribed on the disk at intervals of one-tenth inch, to facilitate laying out successive airplane positions along the dead reckoning course when the speed of the airplane and time interval between photographs are known.

## Orientation of Photographs and Plots

The proper orientation of the plottings from aerial photographs is a puzzling problem if no ground control exists, but it can be accomplished by the utilization of reflections or shadows from the sun. It is obvious that the sun's reflection will have the same bearing as the sun. If the true azimuth of the sun is calculated the azimuth of the principal plane is then readily found from the bearing grid. Such a reflection is rarely sharp, and it is only possible to estimate

the bearing to the nearest one or two degrees; but the method is a direct one.

The determination of orientation by shadows is based on well-known principles of perspective. Since all "sun lines" on a photograph joining the tips of peaks with the tips of their shadows emanate from the sun, they are parallel, as the sun is for all intents and purposes at an infinite distance away. Consequently, they will converge

FIG. 25—Construction of sun lines on an aerial photograph with shadows and projection to perspective point. Photograph taken "down sun."

to a vanishing point in the plane of the negative, provided the photograph is not taken exactly at right angles to the sun.

In a photograph taken with the sun behind the plane of the negative, such as Figure 24, the vanishing point is the shadow of the camera on the ground and could be checked as such, provided the shadow could be seen. In a photograph taken against the sun the vanishing point is the sun itself. If the vanishing point of the "sun lines" is within the limits of the negative the desired angle can be found at once by superimposing the proper bearing grid and noting the bearing angle of the point of intersection of the "sun lines" with reference to the principal plane. If the vanishing point lies outside the boundaries of the negative, as in Figures 25 and 26, it must be fixed by prolonging the "sun lines" beyond the boundaries and determining the corresponding bearing angle by calculation.[16]

The method of determining azimuth by the use of shadows or reflections has the great advantage that it can be checked approximately by calculating from the results of the azimuth determination the altitude of the sun and then comparing this altitude with that calculated from the known geographical position. The numerical work is somewhat long; but, where the orientation of a large group of bearing plots depends upon the degree to which three or four

[16] The author submitted with his manuscript several worked-out examples of these calculations. Space, however, was not available to print them, but it is understood that they will eventually be printed in full in the final scientific reports of the Byrd Antarctic Expedition.—EDIT. NOTE.

azimuths are found, the work is well justified. If equidepression grids (see note, p. 198) are available, the altitudes can be picked off by inspection. When only one shadow can be used, then the orienta-

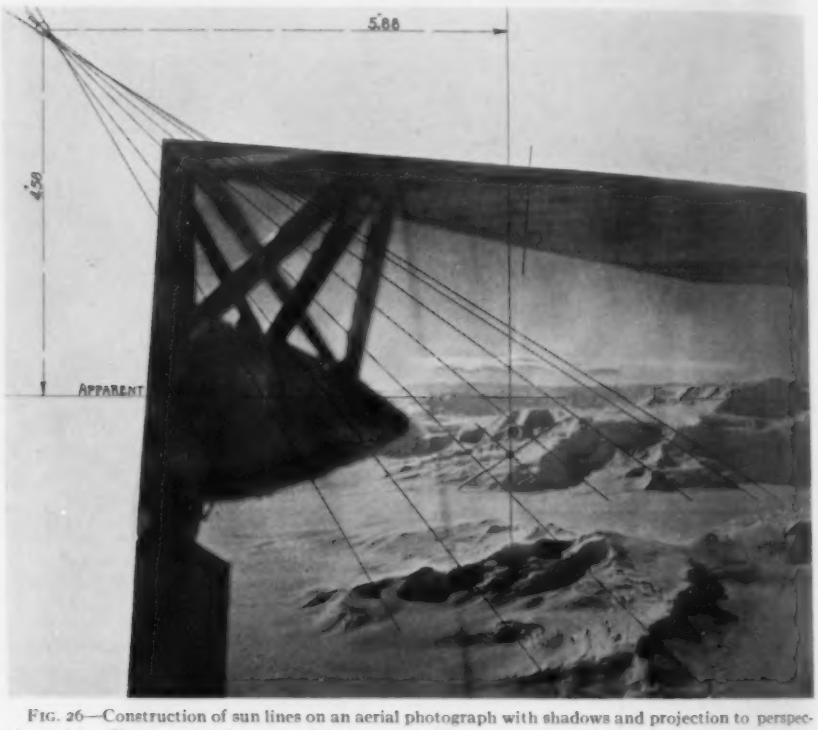


FIG. 26—Construction of sun lines on an aerial photograph with shadows and projection to perspective point. Photograph taken toward the sun.

tion of the photograph may be determined by using the "sun line" in conjunction with the computed altitude.

In plotting oriented lines on the plotting chart it is convenient to construct a sun azimuth rose for the range of time covered by the photographs analyzed. Azimuth may be transferred from the rose to adjacent parts of the chart by parallel rulers. The errors involved in this approximation are generally quite small and probably well within the limits to which the "sun lines" themselves can be drawn.

One method, though admittedly lacking in accuracy, is given here as an example of the necessity for using every source of information that might prove of the slightest value in plotting or preparing reconnaissance maps.

In some areas, as on the South Polar Plateau, there were found long drifts of snow (Fig. 27) in the lee of the ice ridges, or zastrugi, left by the last previous blizzard. In such open areas it was reasonable to assume that within the limits of the field of view of the camera in a series of successive photographs the blizzard wind had blown

from a fixed direction and had left the drifts of snow all parallel to one another. The lines of these drifts, if prolonged, should then all meet at one point on the true horizon. The position of this point enabled the photograph to be oriented with respect to the lines of drifted snow. For example, at one point on the South Polar flight, opposite the Thorvald Nilsen Mountains, survey photographs were taken to west and to east on opposite sides of the airplane. Those taken to the west showed the details and relative position of the peaks of a new mountain range[17] but apparently without the least information that would enable them to be oriented accurately. It was observed, however, that lines of drifted snow appeared in photographs taken to the east as well as those to the west; in addition to which, a distinct reflection of the sun on the ice surface of the plateau was recorded in the easterly photographs.

FIG. 27—Survey photograph showing lines drawn over parallel drifts of snow, terminating in a perspective point in the trace of true horizon. The drift lines lie at an angle of 7.3° to the right of the principal plane.

Plotting and determining the azimuth of the drift lines for the latter photographs was a simple matter, especially as these lines lay within 1° of the true azimuth of the sun. Adding 180° to the azimuth of the drift lines immediately oriented those in the westerly photographs, whence the approximate azimuths of the principal plane of each westerly photograph were determined.

## SCALE DETERMINATION

In making the map, one of the biggest problems was the establishment of scale. It will be obvious that a group of landmarks may be assembled on a sketch map into their correct relative positions without any information whatever as to the correct distance between them.

However, even when ground control points were entirely lacking, several approximate solutions to the problem were found practical. For instance, when there was somewhat in the foreground of the photograph a considerable region at sea level and the altitude of the

[17] See the map of the Antarctic Regions (inset of the South Pole Flight, 1 : 4,000,000) accompanying Captain Ashley C. McKinley: Mapping the Antarctic from the Air, *Natl. Geogr. Mag.*, Vol. 62, 1932, pp. 470–486. These peaks are apparently at the head of dissection of the scarp front.

airplane was known, a perspective grid was used to establish distances between selected points, from which other distances were computed or plotted. For example, note the open water area depicted in the photograph Figure 20.

If the ground under the airplane was irregular and of unknown

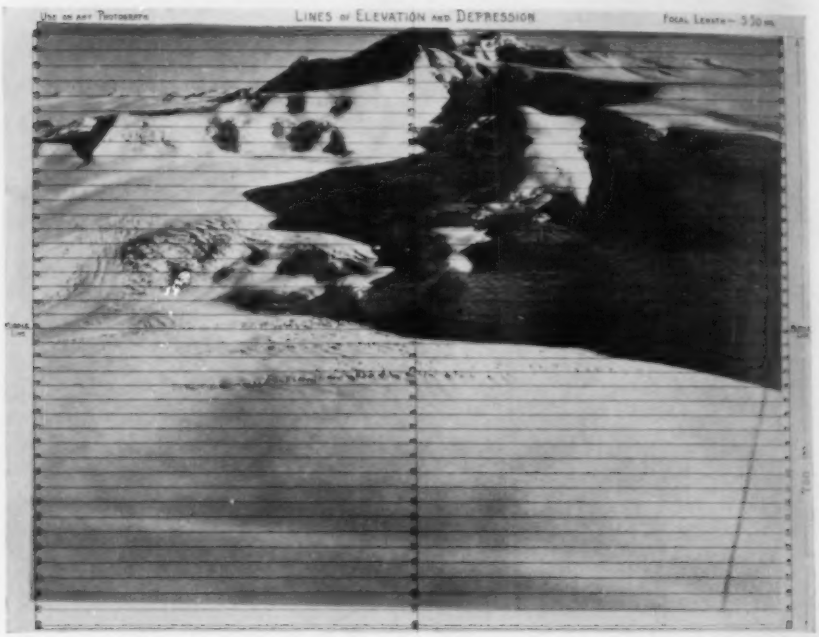


FIG. 28—Grid with lines of elevation and depression applied to an oblique aerial photograph. The center of the grid is applied over the center of the photograph, with the lines parallel to the apparent horizon.

height above sea level, but the altitude of the airplane was known, the best that could be done was to estimate the altitude of one or more of the landmarks and from the depression angles compute their distances from the airplane. With these as a basis, the remaining distances were determined.

An estimate of the distance flown by the airplane in a given interval, under known conditions of loading, altitude, engine revolutions, and direction and velocity of the true wind, while admittedly approximate, was the only available method in certain circumstances. It was by navigational control such as this that the longitude and approximate position of Okuma Bay were determined.

## DETERMINATION OF HEIGHTS

To estimate the absolute or relative heights of peaks and landmarks whose distances from the airplane are known, or to perform the reverse operation, it was found desirable to have a ready means

of determining vertical angles on a photograph somewhat more convenient than the formulas described by Bagley.[18]

When the number of vertical angles to be picked from a photograph is large it will be worth while to add equidepression lines to the bearing grids (note 15, p. 198). A horizontal bearing grid (con-

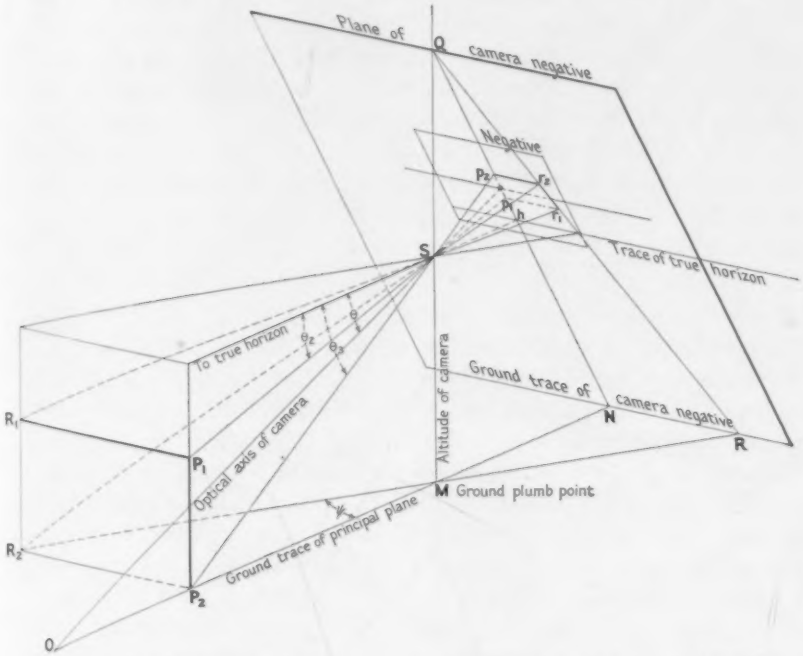


FIG. 29—Geometrical diagram for lines of elevation and depression on an oblique aerial photograph. The triangle $SP_1P_2$ is a projection of the triangle $SR_1R_2$ upon the principal plane of the negative.

structed for photographs having no tilt) may be used for the purpose of obtaining heights by rotating it 90°; but a special grid, constructed along the lines illustrated in Figure 28, is much more convenient.

The vertical angles represented by the horizontal lines on these grids are true when in the principal plane; but they are applicable to objects either in or out of the principal plane, provided they are used in conjunction with the distances measured from the airplane position to the positions of the objects as projected perpendicularly to the principal plane.

In Figure 29, drawn in isometric projection, $R_1$ represents a peak and $R_2$ the point in the ground plane directly under the peak. Assuming that the point $R_2$ were visible on the negative, the two images $r_1$ and $r_2$ would lie on a diagonal line of bearing. If the points $R_1$ and $R_2$ are projected back to the principal plane of the camera, that is

[18] J. W. Bagley: The Use of the Panoramic Camera in Topographic Surveying with Notes on the Application of Photogrammetry to Aerial Surveys, *U. S. Geol. Survey Bull. No. 637*, 1917, pp. 64–86.

to $P_1$ and $P_2$ respectively, the height of $P_1P_2$ will be equal to $R_1R_2$, and the depression angles $\theta_2$ and $\theta_3$ can be measured directly in the principal plane. By the construction of a grid consisting of a series of straight lines perpendicular to the principal plane representing integral angles of depression and elevation, the difference of vertical angle between the projection to the principal plane of any two points on the photograph may be determined by inspection.

Such a grid must always be placed with its center over the principal point of the photograph, and the lines on the grid must be placed parallel to the apparent horizon.

Since $R_2P_2M$ is a right angle and $R_2$ lies at an angle of bearing $\psi$ from the principal plane, the distance from the plumb point to $P_2$ is equal to $MR_2 \cos \psi$.

## Detailed Plotting Procedure

So much for method. The application of all the methods previously described to the plotting of the flight as a whole and to the delineation of the features discovered will be briefly described.

In the whole region covered by the flight, extending for 50 miles on each side, there were only five known landmarks. Of these, Okuma Bay and Cape Colbeck were marked by the edges of thick shelf ice which might or might not have remained in position for the eighteen or more years since they had previously been visited.[19] Furthermore, the known geographical positions for those points were obtained on ships at sea and not on the land.

The position of Gould's camp in the Rockefeller Mountains had been determined by him in March, 1929; but it lay far from the line of flight and was, moreover, the position of a camp in a valley and not a visible peak. The position of La Gorce Mountain was known only by its bearing from Gould's camp.

The principal ground control, in fact the only control adjacent to the line of flight, was the pair of peaks called Scott's Nunataks, which had been visited by Prestrud in December, 1911. Prestrud, in the account of his sledge journey, reports having determined his position but does not give the figures.[20] In one of the reports dealing with the scientific results of Amundsen's expedition[21] the location of Scott's Nunataks is given as "about latitude 77° 13′ S. and longitude 153° 20′ W." This value has therefore been used on the map and applied to the slightly higher, more easterly, of the two peaks.

[19] Scott, in the *Discovery*, took soundings in Okuma Bay in 1902 as indicated on the general map in 1 : 5,500,000 accompanying the work cited in footnote 7 above, but there is no information to fix the shores of the bay. Shirase, in 1912, visited Okuma Bay (see footnote 6): his positions were 77° 50′ S.—158° 30′ W. and 77° 50′ S.—158° 40′ W.; but, again, they are not sufficient to establish the outlines of the bay.

[20] Amundsen, *op. cit.*, Vol. 2, p. 258.

[21] J. Schetelig: Report on Rock-Specimens collected on Roald Amundsen's South Pole Expedition, *Videnskapsselskapets Skrifter: I, Mat.-Naturv. Klasse*, Christiania, 1915, No. 4, p. 3.

As the airplane left Little America the headings and drift angles varied slightly, but the course made good over the ground averaged about 57° true. The steering of this constant compass course took the airplane in a curved line over the earth, because of the divergence of the meridians of longitude in these regions. Assuming an average ground speed of about 115 miles an hour and a dead reckoning time of 11.42 a. m. abreast of Okuma Bay, the estimated distance from Little America was about 97 miles. The plotting of the 11.42 a. m. position in this manner placed Okuma Bay about on the meridian of 158° 35′ W., a result that agreed reasonably with the reckoning of Prestrud and the observations of Shirase.

When McKinley began photographing, opposite Okuma Bay, he took a number of photographs to seaward, toward the bay and toward Cape Colbeck, almost directly into the sun. The azimuths of the principal plane of these photographs, taken from the sun's reflection on the water, gave good checks on the true course of the airplane. It was possible to check the course and position of the airplane from the bearings of two of the peaks of the Rockefeller Mountains lying on the opposite side of the airplane toward the southeast.

The holding of the dead reckoning course to Scott's Nunataks, checked by frequent photographs toward the sun in the direction of Biscoe Bay, made it possible to orient the photographs of the Alexandra Mountains and the La Gorce Mountain group with reference to the control point at Scott's Nunataks. From the bearings on these photographs it was possible to place the position of La Gorce Mountain along the known line of bearing from Gould's camp in the Rockefeller Mountains and to make its distance from that camp about 50 miles instead of 70, as previously estimated.

Thanks to the considerable overlap that McKinley took care to include in his photographs and to the hand of a kind Providence which placed Mt. Grace McKinley and the Haines Mountains at a convenient interval between King Edward VII Land and Marie Byrd Land, it was possible to continue the plotting, by lines of bearing, all the way from the Alexandra Mountains to the Edsel Ford Range, despite the 40° change of course of the airplane at 1.13 p. m. to the left of its original course. While it is possible to make a partial round of bearing angles when the airplane is making a large change of course by using bergs and other objects in the foreground, it is far preferable and much more accurate to use objects that lie at a considerable distance.

From the 1.48 p. m. position, where the course was changed to about 75° true in order to approach the Edsel Ford Range, to the 2.10 p. m. position, only one photograph was taken toward the south, that is toward the landmarks recorded on the preceding photographs. Two photographs taken shortly thereafter, showing open sea to the

north of the airplane, unfortunately show no known landmarks and have no shadows sufficiently large for purposes of orientation. The direction of the open sea remains therefore somewhat indefinite.

What appears to be a fairly high cliff marking the seaward edge of thick shelf ice well to the eastward of the airplane track appears in the photographs taken just after the turn toward the south at 2.10 p. m.; but the photographs show no definite landmarks, and the visible stretch of shelf edge is well beyond the boundaries of the map in about latitude 74° 30′ S.

Again, after making the turn at about 2.55 p. m. to investigate the appearance of islands to seaward, a number of photographs were taken on the northerly part of the circle, but there were no known landmarks and no shadows sufficiently large for proper orientation.

On the return to the south, from the 3.15 p. m. to the 4.25 p. m. positions, the airplane flew nearly parallel to the Edsel Ford Range but at a great distance from it, varying from 90 to 115 miles. Identification of the mountain groups was difficult, although eventually possible; plotting by resection was then more or less straightforward.

One or two interesting problems in identification encountered on this part of the flight may be briefly described.

On one photograph, taken nearly "down sun" at about 3.28 p. m., there was visible on the distant horizon a triangular white spot, having more the appearance of an imperfection on the negative than a mountain peak. However, by bearing angles it was found that it lay very nearly in the direction of the solitary Hugh Mitchell Peak. Examination of photographs taken just before and just after showed the same triangular white spot but at different bearings. These, when plotted, not only showed conclusively that the object *was* Hugh Mitchell Peak but when so proved offered one more definite landmark for resection purposes.

The part of the return flight from about 2.50 to 3.50 p. m., in which search was made for islands seen to the northwest on the outward flight, involved two separate crossings of the outward track of the airplane. The loop thus made involved difficult and uncertain plotting because, as previously described, no known landmarks were visible and no shadows were available. It was most important, therefore, that the track be defined in some other way, especially as the airplane position of one of the later photographs with shadows—a most important one, facing the whole Edsel Ford Range—had to be determined with the greatest possible accuracy. After considerable search among the photographs two groups of bergs were discovered in about latitude 76° 55′ S., longitude 149° 40′ W., that were visible in the photographs taken both on the outward flight and on the return. Other landmarks in about latitude 76° S., longitude 146° 30′ W., likewise appeared in the two sets of photographs.

The American Geographical Society of New York

# RECONNAISSANCE MAP OF KING EDWARD VII LAND AND THE NORTHERN PART OF MARIE BYRD LAND

Based mainly on air photographs taken by Capt. A. C. McKinley on the
BYRD ANTARCTIC EXPEDITION 1928 – 1930
Rear Admiral RICHARD E. BYRD, U.S.N. (ret.) in command

Constructed by Harold F. Saunders, Commander (C.C.), U.S.N.

Scale 1:1,500,000

Kilometers 0 10 20 30 40 50 60 70
Statute miles 10 0 10 20 30 40

Mountains and mountain peaks (rock exposures in black)
Inland ice (continental ice sheet)
Thick shelf ice
Thin shelf ice or old sea ice
High ice cliffs
Low ice cliffs
Crevasses
Ice islands
Pack ice
Open water
1700 1548 Elevations and depths in feet

Conditions as in Dec. 1929

Route of the airplane flight of Dec. 5, 1929
Route of the airplane flight of Feb. 18, 1929, to the Rockefeller Mountains
Approximate route of the "City of New York," Feb. 13–14, 1929
Route of the "Discovery" (Scott), Jan. 29 – Feb. 4, 1902
Approximate route of the "Kainan Maru" and landing party (Shirase), Jan. 13–Feb. 12, 1912
Approximate route of Prestrud's sledge journey, Nov. 20 – Dec. 16, 1911

⊕ Astronomically determined positions (furnishing the ground control of the map)
3:36 PM Bearing of the sun on Dec. 5, 1929, at the points indicated as deduced from shadows on the air photographs
3:45 PM Position of the airplane at the local mean time of Little America (180 th meridian time, taken as 12 hours slower than Greenwich civil time)
A → Positions on airplane track of Dec. 5, 1929, at which photographs in the accompanying text were taken

On the method of constructing the map from the air photographs see the accompanying article
All names except those that are underscored are derived from the Byrd Antarctic Expedition

Lambert's conformal conical projection with 75°30′ and 77°30′ as standard parallels

Sun Azimuth Rose for 150° W
Time Scale: local mean time of Little America

ROSS SEA
ROSS ICE SHELF
BISCOE BAY
KING EDWARD VII LAND
ALEXANDRA MOUNTAINS
ROCKEFELLER MOUNTAINS
ARTHUR SU

Cape Colbeck
Okuma Bay
Kainan Bay
Bay of Whales
West Cape
LITTLE AMERICA 78° 34′ S. 163° 46′ W.
"Kainan Maru" Jan. 23-24, 1912
Scott's Nunatak 77° 13′ S. 153° 20′ W. (Prestrud)
Mt. Nilsen 13000
Mt. Helen Washington 11800
Charles Gould Peak
Tennant Peak
Gould's camp Mar. 7–22, 1929 78° 09′ S. 154° 27′ W.
John Bowman 11900
La Gorce 12700

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151° 150° 149° 148° 147° 146° 145° 144° 143° 142°

open water lanes

loose pack ice

open water

many bergs and grounded ice islands

thin shelf ice

UNIV. OF MICH.

Azimuth Rose for 150° W. Time Scale: local mean time of Little America

10:00 11:00 12:00 1:00 2:00 3:00 4:00 5:00

undulating surface

2:10 PM

1:48 PM

inland ice with irregular slopes

ice cliff

grounded ice islands surrounded by sea ice

investigating appearance of islands to seaward

thin shelf ice

old sea ice with drifted snow

crevasses

undulations

land underneath

land edge ?

3:15 PM

grounded ice islands

Jan. 25, 1912

old sea ice

ice cliff

land underneath ?

land edge ?

Mt. Harold June 3700

PAUL BLOCK BAY

LAND

Hugh Mitchell Peak 1200

Birchall Peaks 2000

Mount Iphigene 4200

Bozzit Baldwin Glacier

Raymond Fosdick Mts

Mt. Ayers 4500

Mt. Supu Peak 3000

Adair Oates Glacier

Harold Tapley Plateau 5000?

low outcropping rock ridges

RANGE

covered old cracks with snow

thin shelf ice

thick shelf ice

low ice cliff

very large ice islands

3:38 PM

1:13 PM

land underneath ?

ARTHUR SULZBERGER BAY

floe

thin shelf ice

a berg

bergs

open water

sea ice with cracks

ice cliff land underneath ?

hills

inland ice

Saunders Mountain 4200

FORD

thick shelf ice

thin shelf ice

bergs with open water

many bergs

land underneath

crevassed edge

open water

crevasses

4:25 PM

Mount Rea 3900

Donald Woodward Mountain 3000

inland ice

BYRD

John Bowman Peak 1900

MOUNTAINS

low hills

crevasses

Haines Mountains (snow covered) 2600

FIELDSEL

La Gorce Mountain 2700

LAND

irregular undulating snow covered hills

Grace McKinley 2500

MARIE

Eastern Boundary of Ross Dependency

75°

75° 30'

76°

76° 30'

77° S

77° 30'

78°

78° 30'

152° W 151° 150° 149° 148° 147° 146° 145° 144° 143° 142° 141° 140° 139°

A. Hoen & Co., Baltimore, Md.

As is frequently the case when a group of landmarks are plotted by resection, or by lines of bearing, it was found that the entire Edsel Ford Range, when the individual mountains were all plotted in their correct relative positions, could be moved bodily over a considerable area, in a north and south direction. To fix the position of the group, the series of photographs had to be correctly orientated. Fortunately, on a few photographs there were shadows on icebergs fairly close aboard, small shadows, to be sure; but on one photograph in particular, taken almost directly "down sun," the sun line intersection was sufficiently definite to be reliable. The bearing plot from this one photograph served as a confirmation of the plotting for almost the entire eastern half of the flight.

At the 4.20 p. m. position, about abreast the open water area in latitude 77° 20′ S., longitude 149° 20′ W., photographs were taken in succession of the Alexandra Mountains on the west and the Edsel Ford Range on the east. With bearing plots to be adjusted from opposite sides of the airplane course, it was obvious that the relative positions of the two groups of mountains had to be very nearly correct. Actually, if laid out in exact agreement with the bearing plots, the mountains would lie some 169 miles to 171 miles apart; although this distance is doubtful because the mountains of the Edsel Ford Range were 116 miles away and, with the sun shining directly upon them, showed little contrast in the photographs. The two groups of mountains as plotted on the map lie only 163 miles apart. The difference may be partly ascribed to the use of a focal length of 9.50 inches for the camera in preparing the grids instead of the actual length 9.36 inches. This would reduce the discrepancy by 1½ per cent, or some 2.5 miles. The remainder must for the present be ascribed to errors in plotting due to lack of reliable ground control.

After passing La Gorce Mountain on the return flight and turning northwestward, a series of photographs was taken between 4.55 and 5.07 p. m. of the Rockefeller Mountains to the southwest. Interspersed with these photographs, however, were a number taken on the starboard beam, toward the north and northeast. In two of the latter Scott's Nunataks appear, and bearing checks from both sides of the course were thus possible.

Unfortunately, a number of peaks in the Alexandra Mountains presented such a different aspect when viewed from the opposite side that identification and correlation with the photographs on the outward journey were found impossible.

On the return flight past Okuma Bay the airplane track lay some miles farther inland than on the outward flight. One excellent photograph of the bay and of the shore line northward to Cape Colbeck was obtained, which served to confirm the bearing and the contour of that part of the coast.

# THE RAINY SEASON OF 1932 IN SOUTHWESTERN ECUADOR

George Sheppard

TRUE to the seven years' cycle recognized as obtaining in southwestern Ecuador, the rainfall of this region was abnormally heavy in 1932, repeating the phenomena of 1925.[1] The author was fortunately able to observe various incidents of meteorological interest which took place during the rainy season, January to May, at Ancon on the southern side of the Santa Elena Peninsula. A detailed record was kept, and this is on file at the American Geographical Society. Although it has been customary to refer to years of heavy precipitation in this part of the world as "abnormal," one is now led to the view that their occurrence is quite in order as a natural climatic sequence.

## Unusual Migration of Sea Birds

After the rainy season exceptional movements of birds were noticed in the Santa Elena region, the species observed being rarely seen in this district during normal years, the last occurrence of such phenomena being noted by the writer during the heavy rainy seasons of 1925 and 1926. A few birds were seen about the first week in May, or possibly earlier. During the first two weeks in June they appeared in great numbers. Most of these birds, probably all, traveled from the south; and in the majority of cases the flighting was generally northwards. Occasionally, however, large contingents followed the open expanse of the Gulf of Guayaquil inland; hundreds of birds, described in the local press as *patos cuervos*, were left stranded in the city of Guayaquil and its immediate district, and not a few penetrated inland almost as far as the Andes at Bucay and Huigra. During the 7th, 8th, and 9th of June the numbers reached their maximum. On the coast near Chanduy an endless succession of thousands upon thousands of birds, all flying low and in the same northerly direction, was seen throughout most of June 9. Dead and dying birds littered the beach and almost every small cliff or sheltered crannie in the rocks was seen to be occupied by melancholy groups of twenty or thirty birds huddled together in a weak or dying condition. The small inlet to the north of the settlement of Puerto Chanduy was

[1] R. C. Murphy: Oceanic and Climatic Phenomena along the West Coast of South America during 1925, *Geogr. Rev.*, Vol. 16, 1926, pp. 26–54.

literally black with a concentration of them, the majority being too emaciated to raise themselves from the surface of the water. Generally speaking, the birds appear to be of three varieties, most of them being guano birds (*Phalacrocorax bougainvillii*)—black cormorants with white breasts, which walk after the manner of a penguin—others include a large booby (*Sula variegata*) with white head and breast, slate-colored bill, and speckled wings and tail of a brownish color, and finally a small smoke-colored sea bird. No frigate birds were present, and pelicans were rare.

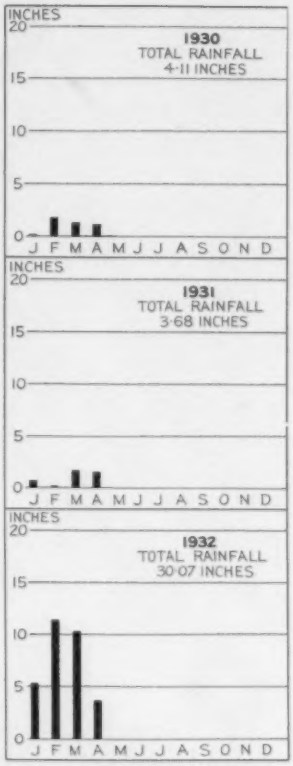


FIG. 1—Rainfall at Ancon, southwestern Ecuador, 1930–1931. Compare the graphs for 1925–1929, work cited in footnote 2, p. 447.

There is little doubt that the physically weak state of the birds has been caused primarily by the lack of suitable food, a condition of starvation which has been responsible for the wholesale migration in search for waters containing the essential varieties of fish life that form the principal food of these creatures. According to the writer's personal observations, which are corroborated by the opinions of the inhabitants of the district, such manifestations of bird movement only occur after seasons of heavy rainfall; and it is clear that this climatic factor has been the cause of the abnormal phenomena described above. There are two causes that may be responsible for the destruction of the food supply of these birds, (1) the displacement of the Humboldt Current by the warm "Niño" current from the north, and (2) local lowering of the salinity of the sea near the coast by the sudden influx of enormous volumes of fresh water from a land surface normally dry. One must always take into consideration the Gulf of Guayaquil, the largest outlet on the west coast of South America, which drains an enormous region of both Ecuador and Peru and into which enormous quantities of fresh water are introduced as a result of a heavy rainy season.

## CHANGES IN THE LANDSCAPE

One of the most striking features of a heavy wet season in this part of the world is the rapid change that takes place from a lifeless, semiarid landscape to a verdant and attractive-looking countryside,

enriched by flowers in great variety and enlivened by bird and insect life in astonishing profusion.

After only a few weeks the grass attains a height of two to three feet. Trees and shrubs also that for years have been practically dormant suddenly burgeon forth and assume the appearance that one associates with tropical vegetation. On the other hand, the true xerophytes, such as members of the Cactaceae, do not flourish during a wet season. They are quickly overgrown by parasitical plants and, losing their rich green color, present an unhealthy and dejected appearance.

FIG. 2—A cactus smothered by parasitical growth as a result of the exceptional rains of 1932.

The cliffs along the coast to the west of Ancon, however, even at the close of the present rainy season, are completely devoid of vegetative covering (Fig. 4). The cliffs are composed of a clayey deposit which, in places, is poorly stratified. The coast line is also oriented directly at right angles to the prevailing rain-laden winds of the winter season, viz. from the southwest. Along this section of the coast there is no protective covering of calcareous Quaternary *tablazo* as in other parts,[2] and the soft clay formations are easily and rapidly eroded by rain. During the showers the surface soil is continually in movement, and it is almost impossible for seeds to germinate, the result being that the deeply eroded and dissected cliffs at this place retain their barren appearance which is in striking contrast to the remainder of the countryside.

The action of periodic rains is also seen in the fretted *quebradas*, an excellent illustration of which from the desert *tablazo* near Talara, Peru, is given in the photograph, Figure 20, of Robert Shippee's article on "The 'Great Wall of Peru' " in the January, 1932, number of the *Geographical Review*.

[2] George Sheppard: Notes on the Climate and Physiography of Southwestern Ecuador, *Geogr. Rev.*, Vol. 20, 1930, pp. 445–453.

FIG. 3

FIG. 4

FIG. 5

FIG. 3—Luxuriant vegetation in the normally dry coastal zone of southwestern Ecuador, following the rains of 1932.

FIG. 4—Rain-dissected cliffs west of Ancon. They retain their barren appearance even in a rainy season.

FIG. 5—An *albarrada*, an artificial reservoir built for water storage during dry years. This *albarrada* forms the water supply for the village of Tambo Arriba near Santa Elena.

Although it can be said that in general most of the soil of the Santa Elena Peninsula is of extraordinary fertility, given the requisite factor of an abundance of water, there are certain areas of a rich, black earth, recalling the well known chernozem of Russia, that support an exceptionally profuse vegetation. In southwestern Ecuador these black-earth patches are found usually above the calcareous *tablazos* of Quaternary age and by some authorities are considered to have been derived from loess, or similar superficial deposit. In the writer's opinion, however, these areas in Ecuador represent ancient lake beds which supported a dense tropical growth of aquatic vegetation and, as such, furnish additional evidence of periodic rainy seasons in bygone times. On the other hand, viz. on the higher parts of the pampa, where the surface is sandy and drainage rapid, the vegetation attains only a moderate growth, such districts being characterized by barren patches.

## Rainfall Periodicity and the Water Supply

From time immemorial the inhabitants of the dry coastal zone have used artificial ponds, *albarradas*, which are filled only during the wet years and, as such, are sufficient to ensure a supply of water for domestic and other purposes for a succession of dry years. These artificial reservoirs, primitive though they are, are additional evidence, from the human standpoint, of the periodicity of years characterized by exceptional precipitation. The ancient fragments of pottery, etc., found in the vicinity of the ponds or lakes suggest a pre-Spanish culture—probably of the Caras—though it is evident that the Spanish colonists improved existing structures by introducing masonry in the dams, which impounded the waters of a river course draining a large catchment area, and by providing spillways. Near La Libertad the large Albarrada de Engoroy—the principal source of water for the inhabitants of the district and possibly a source for Spanish ships frequenting the coast in colonial days—has been formed in the first instance by the construction of a dam across a watercourse. During December of every year, that is before the advent of possible rains, the population of a settlement usually turns out *en masse* to repair or to increase the height of the impounding wall of the village reservoir. That many of the *albarradas* of this district are of great age is proved by the presence of large algarroba trees on the embankments, which must, in many cases, be hundreds of years old.

The periodicity of these winters of exceptional rainfall are an accepted occurrence in the life of the people of the region. The tradition that *años de abundancia* will undoubtedly follow series of dry years is ingrained, and, although the author has knowledge of an occasional settlement being abandoned on account of water shortage,

this has been temporary only. At times, during the stress of extreme aridity, the government becomes interested in vast and ambitious irrigation projects to transform whole tracts of semiarid country into arable land. It is questionable, however, whether the time is yet opportune for any such schemes, even were they technically feasible.

## Résumé of Weather Conditions

During the winter months of 1932 in southern Ecuador the wind direction was variable, with north and northeast winds largely replacing the prevailing south and southwest winds of the summer months (May–December). It must not, however, be assumed that the northerly winds at Santa Elena are entirely rain-bearing. Whilst a certain amount of precipitation was recorded from the landward direction, chiefly in the form of light showers, the heaviest rainstorms were directed from the sea by the south and southwest winds. Local storms of a cyclonic nature also occurred, these being usually accompanied by thunder and lightning, in addition to heavy rains. During the most severe storm of the year, viz. that of March 27, when a precipitation of 5.2 inches was registered, the wind blew generally from the southwest. This storm was not local, heavy showers being recorded from various localities throughout the country. Outside of the coastal zone, i.e. from Manta south to the Santa Elena Peninsula, a terrific thunderstorm occurred at Quito on this date. On March 25 a "hurricane with thunder and lightning occurred around the town of Pascuales (north of Guayaquil) with terrible violence," whilst at Manta on the 28th a large waterspout was observed in the bay, a rare phenomenon along the Ecuadorian coast and one undoubtedly signifying an atmospheric disturbance of considerable magnitude.

A general résumé of the weather conditions throughout the period follows.

*January.* When it was not actually raining the weather was generally sunny and oppressively hot. Rain was first noticed near the Cordillera de Colonche on the 5th, but the first shower recorded at Ancon was on the 8th. The heaviest rainfalls were on the 12th and 18th with 1.81 and 1.11 inches respectively. The total for the month was 5.07 inches. No very high sea-water temperatures were recorded, and towards the end of the month a slight cooling was noticed, accompanied by a resumption of the normal direction of the current from the south.

Towards the end of January, the low-lying regions in the vicinity of Babahoyo became completely inundated by flood waters from the Guayas River, a fact that indicated a considerable rainfall in the mountain districts farther inland. Enormous quantities of flood water were released into the Gulf of Guayaquil, and, according to one observer, the current so caused was felt as far as the Island of Puna irrespective of the tides. Although it has been stated[3] that the presence of exceptional

[3] G. Schott: Der Peru-Strom und seine nördlichen Nachbargebiete in normaler und anormaler Ausbildung, *Annal. der Hydrogr. und Marit. Meteorol.*, Vol. 59, 1931, pp. 161–169, 200–213, and 240–253; *idem:* Der Peru- oder Humboldtstrom, *Forschungen und Fortschritte*, Vol. 7, 1931; *idem:* The Humboldt Current in Relation to Land and Sea Conditions on the Peruvian Coast, *Geography*, Vol. 17, 1932, pp. 87–98.

bodies of water in the Gulf of Guayaquil and elsewhere has no effect on the general climate, it is believed that such an occurrence as the one described has a local, if temporary, influence upon the climate of the Santa Elena Peninsula.

*February.* The relatively dry period occurring from the latter part of January through early February, the *veranillo*, little summer, coincided with lower sea temperatures. Rains began on the 10th and continued until the 17th, recommencing on the 22nd. The total rainfall for the month was 11.3 inches, the curve following closely that for 1925. The greater part of the rain fell during the early hours of the day, generally beginning about 3 a. m. and sometimes lasting until noon. Chimborazo, about 150 miles distant, was clearly visible on the 18th from approximately 6.15 a. m. to 7.15 a. m.

On February 18 an enormous amount of damage was done to the Guayaquil and Quito Railway between Bucay and Huigra, owing to the overflowing of the Rio Chanchan and the consequent flooding of the low-lying lands between Duran and Milagro. In the latter district great devastation was caused amongst the rice and sugar plantations. Landslides or *derrumbes* were common along the railway section between Huigra and Bucay, and at the former station the river changed its course and did considerable damage to property. Heavy rains were fairly general at this time as, according to a press report from Lima, Peru, dated February 19, "the heaviest rains recorded since 1925 occurred yesterday with the result that most of the rivers draining the coast of Peru are rising, and have already caused much damage at the town of Chosica, situated on the railroad about 25 miles from Lima." Great damage was also done at Santa Eulalia, a few miles from Chosica, where heavy landslides, known as *huaycos* from the steep mountain slopes ruined quantities of fruit trees. In 1931 the present author called attention (*Geogr. Rev.*, July, 1931) to the huge masses of discolored water that appeared during the month of February of that year along the coast of Ecuador. No sign whatever of this phenomenon was observed during the present year, and it is now believed that the discolored water in question was shallow bottom water that upwelled or was dislodged by the countercurrent action. Its absence during 1932 can be possibly explained by the fact that enormous quantities of rain water were drained out to sea, along with mud and suspended detritus derived from the land surface, and thus counteracted the local upwelling of the bottom water.

*March.* The weather continued hot, an exceptionally high maximum of 96° F., being recorded on the 10th and the 24th. Rains fell during the middle of the month, including a fall of 1.85 inches on the 18th and of 0.78 inches on the 20th, the latter confirming the prophecies of the local inhabitants who believe that it always rains on the *fiesta* of St. Joseph, which, it so happens, falls on the March equinox. On the 27th a very heavy thunderstorm over the Ancon area produced a rainfall of 5.2 inches. This coincided with the exceptionally high sea temperature of 85.5° F. at La Libertad. The total rainfall for the month was 10.19 inches. The Andes were frequently visible during the month and on the 21st could be seen as late as 10 a. m.

*April.* At the beginning of the month the weather was hot and oppressive (max., 95.0° F.), but on the 13th there were signs of a change, which coincided with a fall in the temperature of the sea water. Rains persisted from the beginning of the month until the 14th, after which it was dry except for a series of small showers from the 24th to the 26th, possibly connected with the wedging of warm and cool waters in Santa Elena Bay, rather marked at the end of the winter season. The rainfall during the month was 3.51 inches, making a total of 30.07 inches since the beginning of the wet season. According to reliable reports the rainfall was generally heavy throughout the country, the figures for Guayaquil (inches) being:[4] January, 19.97; February, 8.81; March, 19.21; April, 19.92, a total of 67.91 inches.

[4] Data kindly supplied by Mr. E. C. Heal, of Guayaquil.

# THE LITTORAL OF NORTHERN CALIFORNIA AS A GEOGRAPHIC PROVINCE

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FIG. 1—The littoral of northern California.

The littoral of northern California is an extremely attenuated natural and cultural province, stretching from San Francisco Bay for more than 300 miles and ranging in width from less than a mile to more than 16 miles. It is best defined physically between Point Reyes and Cape Mendocino, though the area tributary to Humboldt Bay is of greatest importance as regards production and population.

Physically the littoral is a series of grassy wind-swept benches carved out of the seaward border of an elevated and maturely dissected peneplain lying from 1600 to 2000 feet above sea level. In contrast to the coastal benches the higher rugged belt is heavily timbered and sparsely populated. The boundary between the two belts is well defined by the lower tree line which tends to follow the inner edge of the most conspicuous terrace.

Commercially as well as physiographically the communities of the littoral face the sea. In spite of the hazards of the coast, freight moves in and out most easily through the scattered small ports. Only Eureka and Fort Bragg have railway connections with the interior and San Francisco, and the line to Eureka was not completed until 1915. Except for about sixty miles of coast near Cape Mendocino, the littoral settlements have land connections only by a road, graded and mostly surfaced with gravel, which tends to be rough or even stony in places, because the wind sweeps off the finer loose material. Toward Cape Mendocino the coast is so bold and steep, and the settlements so few, that the road strikes inland.

The coast between Cape Mendocino and Point Arena also lacks easy access to the interior, as the few roads across the dissected highland are mostly narrow, steep, and ungraded. From the Russian

River south, three paved roads extend nearly to the sea, connecting with the paved Redwood Highway into San Francisco. This highway reaches the coast of Eureka and continues north along the coast to Crescent City and thence inland. The Roosevelt Highway, also paved, continues north from Crescent City along the coast. A few years ago Crescent City was an isolated provincial village, a full day by stage from Eureka over a very difficult road. The excellent new highway connections have rejuvenated the place.

## The Coast and Its Harbors

With the exception of Humboldt Bay the coast is without natural harbors of any consequence. Eureka, with a population of 15,748 (1930) is the largest port between San Francisco and the Columbia River. It has not only the best harbor but the largest immediate productive hinterland and the easiest access by land. More than $7,000,000 has been spent by the federal government in building jetties a mile out to sea and in dredging the channel 300 feet wide and 20 feet deep at low tide. During 1930 the sum of $187,000 was expended for dredging by the federal and county governments. Beyond the city of Eureka the submerged channel of the Mad River continues a fairway for boats of less than 15 feet draft to the end of a landing projected a mile and a half over the shoals from Arcata. Eighty miles farther north nearly $2,000,000 have been spent in building a breakwater for the comparatively open harbor of Crescent City. Fort Bragg, with a population of 3020, is the second largest port town, not, however, on account of harbor advantages but because of the resources of its back country. Most of the small ports are located on small bays or the mouths of streams which cut across the benches in intrenched narrow valleys that provide easy gradients into the timber belt of the highlands.

Picturesque boldness and irregularity in detail are characteristic of this cliffed, wave-eroded coast, which presents a ragged succession of headlands and reëntrants. The sea is even now actively planing the land border and perfecting a submarine bench cut across upturned strata visible in part at low tide. Stacks, chimneys, and larger rocky island residuals project beyond resistant rocky headlands whose shores are strewn with great boulders. Caves, arches, windows, and other fantastic details have been carved by the waves.

Excepting the bars and barrier beaches at Drake's Estero and Bolinas Bay, depositional features are limited to the comparatively unimportant stretches of the coast that run southwesterly. Such shores trend partly across the prevailing winds, and sands are blown landward forming dune belts, the most notable being the Humboldt Barrier.

FIG. 2

FIG. 3

FIG. 4

FIG. 2—Typical marine bench landscape south of Westport.
FIG. 3—The Sugar Loaf, a residual on the littoral a few miles north of Point Arena.
FIG. 4—Westport, typical of the small weather-beaten lumber ports that have seen better days.

FIG. 5—Cliffs south of Crescent City, where the highlands abut upon the coast.

The general lines of the coast are related to the structures that also determine the major land features. South of Cape Mendocino the coast parallels roughly the structural axis, extending from north-northwest to south-southeast, and the greatly disturbed rock formations of the land are roughly belted in the same direction. The structure is likewise reflected in the remarkable parallelism of the main stream valleys in the coast ranges, which have become adjusted to a subsequent drainage pattern.[1]

The San Andreas fault accounts for the alignment of Bolinas Bay, Tomales Bay, and the comparatively straight coast line to Point Arena. South of Tomales Bay the fault forks in a narrow wedge conforming roughly with the shores of the bay. North of the Russian River the east branch of the fault intersects the coast and is followed by Gualala Valley and a part of the Garcia Valley, while the west branch is believed to be just off shore.[2] The land west of the fault, terminating in Point Reyes, is the only important peninsula on the coast. Bodega Head is a similar but much smaller remnant sheltering a large dune area.

## THE BENCH LANDS

Hardly less conspicuous than the bold coastal features of the present strand are the ancient marine terraces and the residuals of marine erosion that occasionally rise from them. The terraces are seldom more than half a mile in width and range down to nothing where erosion has merged present and ancient cliffs into a single steep slope ascending to the general summit level of the highlands. Some semblance to a series of compartments is suggested in the arrangement and occupation of communities on sections of the coast.

For about sixty miles south and twelve miles north of Cape Mendocino the highlands crowd upon the coast, and the bench lands are generally too narrow for human occupation or have been cut away entirely. On the contrary, around Humboldt Bay and in

[1] A. C. Lawson: The Geomorphogeny of the Coast of Northern California, *Univ. of California Publs. in Geol.*, Vol. 1, Berkeley, 1893–1896, No. 8, pp. 241–271; reference on p. 251.

[2] Bailey Willis: A Fault Map of California, *Bull. Seismol. Soc. of America*, Vol. 13, 1923, pp. 1–12.

the lower Eel River valley a broad embayment of bench lands and alluvial plain extends from five to ten miles from the present coast. The rock material here is softer and less coherent than elsewhere on the coast, being younger sediments lying in the limb of a synclinal trough.[3]

FIG. 6—Old Russian church at Fort Ross settled in 1812.

The timber line, as has been noted, commonly follows the crest of the most conspicuous terrace or the lower edge of the highlands. The wind-swept benches are bare of trees, only cypress or bull pines being able to survive in favored spots as in the shelter of projecting headlands, where groves may extend to the seaboard. South of Point Arena even stunted redwoods may be found in the protected narrow valleys leading to coves on the coast. South of the Russian River the forests retreat from the coast and toward San Francisco are limited to the sheltered mountain slopes, and the grasslands extend over the hills. At the edge of the timber the trees are bent over, flattened out, and stunted, like those of high wind-swept mountain slopes. The thick branches of the cypress give it an advantage in standing up against the wind in compact groves, and it is used to some extent for windbreaks. Attempts to use eucalyptus for the same purpose have met with little success, as these trees may be bent over until they lie nearly prone.

Fences, buildings, and villages are weather-beaten in appearance, and as the summer advances the grass becomes brown and the landscape sere and drab.

## ANOMALIES OF THE CLIMATE

Climatically this littoral is distinguished by strong winds, by an exceptionally low seasonal range of temperature, and by cloudiness and prevalence of fog, especially in the summer months. The coast shares with other western coasts of middle latitudes a subjection to marine influences, here emphasized and restricted by the steep terraced front of the highlands. The striking climatic anomalies are attributed to the upwelling of cold sea water in the early summer, centering about Cape Mendocino and spreading along the coast,

[3] Lawson, *op. cit.*, pp. 255–257.

especially southward as the summer advances.[4] Strong northwest winds, originating from the permanent North Pacific High, sweep the coast, along which they are deflected southward by the highland front. Point Reyes, the most exposed point, has the highest average wind velocity of all places in the United States—20.4 miles an hour, or nearly 27 miles for June.[5] The winds are strongest during the months of May and June and are then most northerly. As the summer advances they take on a monsoon character, being drawn into the heated valleys of central California. From Cape Mendocino north, with the absence of such valleys of large area, the winds are not nearly so strong as farther south (6.6 miles average at Eureka).

The upwelling cold waters off the coast account for the abnormally low seasonal temperature range which is less even than that of southern California. At Point Reyes the range is only 7° F., at Eureka 9.4°, but it increases southward to 11.4° at San Diego. While this coast shares mild winters with the rest of the Pacific coast, its lower range of temperature is due to the exceptionally cool summers, the summer temperatures actually increasing northward from Cape Mendocino to the Washington coast. The temperature anomaly for July is −11.7° F. at San Francisco and −21.5° F. at Point Reyes. The fogs retard the summer maxima, and the warmest month is August north of Cape Mendocino and as late as September for parts south of it. The fogs originating with the cooling of moist air over the cold waters tend to lift or develop "ceiling" as a marked inversion of temperature develops.[6] They check evaporation and thus reduce the effectiveness of the summer dry season but add dull gray skies to a raw and chill atmosphere.

## Early Settlement

The natural differentiation of the northern California littoral is reflected to some extent in the Indian culture, which prevailed practically untouched by direct contact with the whites until the eighteen fifties. North of Cape Mendocino the culture emanated chiefly from the north. Kroeber includes this part of the coast of California with that of southern Oregon as a cultural subprovince. South of the cape the coast Indians shared their culture in the main with all central California Indians.[7] The coast, however, imposed some common elements on the mode of life as distinct from that of the interior, as its large shell mounds bear witness. The treeless areas around San

[4] H. R. Byers: Summer Sea Fogs of the Central California Coast, *Univ. of California Publs. in Geogr.*, Vol. 3, No. 5, Berkeley, 1930, pp. 291–338; reference on pp. 298–302. See especially the charts of surface-water temperatures from H. Thorade, pp. 298–300. Also see the bibliographical references in the article.

[5] A. J. Henry: The Winds of the Middle and Northern California Coast, *Monthly Weather Rev.*, Vol. 54, 1926, pp. 3–5.

[6] Byers, *op. cit.*, pp. 309–320.

[7] A. L. Kroeber: California Culture Provinces, *Univ. of California Publs. in Amer. Archaeol. and Ethnol.*, Vol. 17, No. 2, Berkeley, 1920, pp. 151–169.

Francisco Bay and other favored parts were probably enlarged by fires set by the Indians who depended on hunting and fishing and the gathering of acorns and seeds.

The first exploration of northern California was by sea. Cape Mendocino, a name in use by 1584, records early Spanish exploration on the coast.[8] But no attempt at occupation was made until the later eighteenth century, when under fear of Russian and English activities on the northwest coast efforts were made to safeguard Spanish rights. Trinidad Bay and Bodega Bay were discovered in 1775, and in 1793 an abortive attempt at settlement was made at the latter place.[9] The Russians, however, established a settlement near here, Fort Ross, in 1812. In 1841 the Russians withdrew, selling their improvements at Fort Ross to John A. Sutter. Humboldt Bay, according to report first discovered by the American sea captain Jonathan Winship in 1806, was rediscovered in 1849, and American settlement followed rapidly. The first settlers were mostly mining men, and the first settlements, on Humboldt and Trinidad bays, were supply ports for the gold miners of the Klamath and Trinity rivers. But lumbering soon became the chief occupation and attracted many settlers from the lumber regions of the eastern seaboard, notably Maine, New Brunswick, and Nova Scotia.

## The Lumbering Industry

This industry has played a leading rôle in the settlement and development of the littoral. The first redwood lumber was shipped from Trinidad Bay in 1850.[10] The first sawmill in the Humboldt Bay region was built in that year, and by 1854 there were nine mills operating on Humboldt Bay. The first sawmill in Mendocino County was built on the point at the mouth of Big River; and Mendocino, the oldest town of any size in the county, began with its sawmill in 1864. A mill was built at Noyo in the early seventies and later moved to Fort Bragg.

The largest present-day operations are in the vicinity of Humboldt Bay, where about 6000 men are ordinarily employed. The largest of the mills is at Samoa, on the bar across from Eureka. Other operating mills are located at Eureka, Korbel, and Scotia. South of Cape Mendocino only the mills at Fort Bragg are in operation during the present economic depression, but large mills at Albion, Elk, Casper, Mendocino, and Rockport have only recently been closed down. Broken remnants of landings and abandoned railway

[8] For a summary of early exploration and bibliographical references see Owen C. Coy: The Humboldt Bay Region, 1850–1875, California State Historical Association, Los Angeles, 1929.

[9] H. R. Wagner: The Last Spanish Exploration of the Northwest Coast and the Attempt to Colonize Bodega Bay, *Quarterly of the California Hist. Soc.*, Vol. 10, 1931, pp. 313–345.

[10] Coy, *op. cit.* This is a history based mainly on local records. L. H. Irvine: History of Humboldt County, California, with Biographical Sketches, Los Angeles, 1915.

FIG. 7

FIG. 8

FIG. 9

FIG. 7—Dairy cattle on coastal bench. Note the windswept cypress grove marking the inner border of the terrace.

FIG. 8—Dairy near Bodega Bay. Here natural grasslands extend over the hills.

FIG. 9—One of the larger and better equipped dairies near Manchester.

FIG. 10

FIG. 11

FIG. 12

FIG. 10—Harbor for the lumber mill at Fort Bragg.
FIG. 11—Lumber mill at Caspar.
FIG. 12—Noyo Harbor. Fishing and packing of fish, especially king salmon, is the only industry.

tracks are reminders of a number of "ghost cities" scattered along the coast, and all of the towns bear witness to better days. The present expansion of Crescent City is mostly along streets laid out in the earlier period of its development as a lumber town.

The lumbering industry depends for its resources upon the upland belt of redwood timber behind the true littoral, occasionally bathed by fogs from the sea. The industry so far has been almost entirely a redwood industry, but the belt also produces a large amount of tan oak and has available considerable spruce, Douglas fir, sugar pine, cedar, and hemlock, with small amounts of valuable hardwoods.

The logs are brought by rail down the narrow valleys cut into the margin of the highland and across the marine terraces to the sea. Most of the mills are or were located at the mouths of the streams. The narrow flats at the lower ends of the valleys afford ideal conditions for log ponds, and the embayments at the valley mouths afford modest harborage.

The present slump in the lumber industry, which has closed some of the mills, is due to a depressed market and not to depletion of the timber supply. The areas recently cut appear devastated, and the camps are abandoned; but the redwood reproduces easily, sprouting from the stumps, and the lumber companies have undertaken a reforestation program looking to a permanent supply. Six companies jointly operate a reforestation nursery at Fort Bragg, which each year produces 1,500,000 redwood seedlings, thirty being planted for each one cut. Farther north all the large companies and most of the smaller ones have joined in the Humboldt Redwood Reforestation Association to assure a perpetual harvest of timber. The future of the industry is assured, and the "ghost towns" may rise again.

## Dairying and Grazing

Dairying and grazing are the characteristic industries of the treeless littoral benches, sharing with the highland belt fairly abundant rainfall which increases northward.[11] Growth of succulent grasses has little interruption, though they are browned by the summer dry season and by a short season of occasional frost in winter. The dairy farmer is put to little inconvenience on account of climate, and milk production does not fall off because of either extreme of temperature.

Dairying had an early start in the Humboldt Bay region. In 1855 Humboldt County produced 80,000 pounds of butter.[12] This area remains the most important dairying locality. Humboldt County had 2049 agricultural and dairying farms comprising 797,160

[11] Mean rainfall at San Francisco is 22.5 inches; at Fort Bragg, 37.7 inches; at Eureka, 41.8 inches; at Crescent City, 74.8 inches.

[12] Coy, *op. cit.*

acres in 1930. During that year they produced 800,689 gallons of market milk distributed, 7,230,713 pounds of butter, 434,350 pounds of cheese, and 65,069 gallons of ice cream. The industry is probably carried on more intensively here than anywhere else in the United States. About 22,000 cattle are located on less than 200 square miles of the lower alluvial soils along Eel River and about Humboldt Bay. The dairy herds average 30 to 35 cows to about 40 acres on the valley bottom lands and about twice as much land on the benches.[13] The county has nine manufacturing plants equipped for the making of butter-fat products located at Ferndale, Arcata, Loleta, and local centers.

In Del Norte County the coastal bottom lands tributary to Smith River and Lake Earl correspond to those of Eel River and Humboldt Bay in Humboldt County and support most of the county's 6000 or more dairy cattle. Another area of intensive production is the Point Arena district, where the marine benches and timber-free lands widen to several miles and are broken up into several much eroded terraces. A large creamery at Manchester takes care of nearly all the product. Most of the dairies in this locality have about 30 cows and graze 200 or more acres but vary greatly in size. North and south along the coast the dairies are generally more scattered and less productive. South of the Russian River the dairy belt widens out and spreads over the grassy hills and the Point Reyes peninsula.

The grazing of beef cattle is generally supplementary to the dairy industry, being associated with the less desirable lands. South of Cape Mendocino there are sections of the littoral where beef cattle and sheep entirely take the place of dairy cattle. Many of the dairies of this part of the coast also graze beef cattle as they include rough terrace or timber land in their territory. The largest dairy in the vicinity of Manchester includes 1100 acres, but only 50 dairy cows in a total of about 300 cattle. South of Anchor Bay the narrow marine terrace is stony and studded with fossil stacks and projecting rock masses. Only about a half dozen ranches front about 20 miles of sea coast, but each includes some thousands of acres. The largest includes 12,000 acres managed from Stewart's Point. About one fourth of this is in pasture but grazes only about 350 cattle and some sheep. The appearance of the properties and owners does not suggest the wealth the number of acres implies.

The grazing of sheep supplements that of cattle, and stock owners change from one to the other as market prices change. In the Humboldt region the poultry industry is also getting a good start.

[13] E. B. Watson, S. W. Cosby, and Alfred Smith: Soil Survey of the Eureka Area, California, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1921*, Washington, 1925, pp. 851–881; reference on pp. 856–858.

## Agriculture

The good soils of the Humboldt Bay and Eel River district were promptly occupied. Among the crops in the pioneer community grain naturally had first place. Today forage crops are of first importance, for the coast climate, advantageous for grass, does not favor the growing of most farm staples. A few miles from the coast in sheltered narrow valleys fairly high summer temperatures prevail, and fine apples and other fruits and vegetables are grown, though the scale of production is small. Of some significance is the small beginning of commercial pea growing near Fort Bragg. About 600 acres were leased by the San Diego Fruit and Produce Company in 1930, and eighteen carloads were produced from 180 acres. The peas are planted in January and harvested in June. The experiment is considered a success, and much is hoped for in the development of another resource to supplement the unstable lumber industry.

The soils of the coastal benches are derived from unconsolidated marine deposits that have been weathered and modified since they were laid down. They tend to have a high content of organic matter and are dark gray to dark brown in color. They are generally fertile and friable but locally have little depth. Most fertile are the recent alluvial soils along the larger streams, but south of Cape Mendocino these have no significance. The upland forest soils are light in color and acid; but they are without agricultural interest because of the rough topography and timber cover.[14]

## Fishing

Fishing is less important to the littoral than lumbering, dairying, or grazing, as the industry centers upon San Francisco. The first important center for commercial fishing north of San Francisco is Noyo just south of Fort Bragg. During the past two years, at a cost of $180,000, the harbor in the mouth of the Noyo River has been deepened to ten feet at low tide to enable the larger fishing boats to enter at all times. Halibut, sardines, bass, and other fish frequent these waters; but the present companies handle chiefly the king salmon, salting and packing them in ice for shipment to all parts of the world. The salmon spawn in the rivers but are caught in the ocean. It is expected that the new harbor improvements will invite further development of the fishing industry.

Humboldt Bay is another center of the fishing industry, with a total catch in 1930 of 3,925,000 pounds, about two-thirds of which was salmon and the rest mostly black cod, halibut, and herring. About 150 boats were employed. The industry is also becoming of increasing importance at Crescent City where 50 to 60 boats are sometimes in use.

[14] *Ibid.*

## Tourism and Coast Resorts

The coast of northern California is little frequented by pleasure seekers. The summer climate is too cool, windy, and foggy for good bathing. Aside from the "Bay Cities," which have their own beaches, quiet waters, and cool breezes, there is no important inland population that does not have as easy access to more pleasant climes. The coast features are scenically beautiful, but the coast highway is very little frequented by tourists, except between Eureka and Crescent City, where there is a striking composition of rugged coast, sheltered lagoons, and luxuriant forests of giant redwoods along a magnificent stretch of highway. At the south, on Bodega, Tomales, and Bolinas bays, comparatively unimportant resorts have developed as offering sheltered waters for pleasure boating and fishing and even bathing in unusually warm weather.

# THE BLACK MAN'S INDUSTRIES

Robert H. Forbes

THE native African negro, far from being the stark savage of common imagination, is the possessor of varied though crude cultures to which in some respects civilized peoples are deeply indebted. These cultures, which vary greatly with local environment, though in some details derived from outside sources, are mainly indigenous and are the net result of raw materials locally available, the needs of isolated peoples, and the ingenuity of these peoples in adapting materials at hand to the satisfaction of their living requirements.

In the Sudan particularly, that broad zone of semiarid country extending west to east across Africa between the Sahara and the regions of more abundant rainfall towards the equator, native cultures are more than usually varied, for the Sudan, time out of mind, has been the commercial meeting place and the battleground of the races—of Berbers from the north, of Arabs from the east, of Europeans from the west coast, and, predominantly, of black tribes from the south. From all of these sources ideas and ingenuities have been derived, adapted to local materials, and gathered into cultural groups now characteristic of many native tribes—the sheep and cattle herders, the transporters of produce, the river fishermen, the lakeside dwellers, and the cultivators in many specialized forms of agriculture —rice, cotton, sorghum grains, fiber plants, maize, grass seeds, and dry-farmed crops. We are here most interested, however, in a few of those arts and industries that are of native origin or of native adaptation and that, therefore, afford a measure of negro mentality.

## Iron Industries

Outstanding among the negroid African's industries is his work in smelting iron and in manufacturing from the crude metal the tools and weapons upon which depend his agriculture, the fabrication of his wooden utensils, and his supply of weapons for fishing, hunting, and warfare.

Over great areas of tropical Africa raw materials and climatic conditions are favorable for the development of primitive iron industries. Throughout the Sudan the main source of iron is a ferruginous hardpan—the so-called laterite of the region. This hardpan, which occurs, normally, in sheets not far below the surface, is formed under

conditions of alternating rainfall and desiccation. Meteoric waters, containing carbon dioxide and small quantities of nitric acid formed by the action of electrical discharges upon the air, have carried iron in solution from surface layers of soil down to a point where desiccation intervenes to cause its deposition. These deposits in some regions are mature, the delicate adjustments between rainfall and

FIG. 1

FIG. 2

FIG. 1—Native smelter near Bamako, French Sudan. This type is air-blasted by means of goatskin bellows operating through the openings at the base of the furnace.

FIG. 2—Tall furnaces at Bango, Haute Volta province—twenty feet high, probably self-draught. Access to the tops was by means of notched poles.

desiccation having long since ceased through climatic change. In other regions the process of ore formation is still active. After their formation these ferruginous hardpans may be exposed by erosion or more deeply buried by accumulating sediments. In addition to a high content of iron (see p. 235) certain of these ores contain as much as twelve per cent of water, which facilitates smelting without the use of limestone, a material not readily obtainable in the region.

The natives are skillful in locating exposed deposits richest in iron, and they select the ore by lifting it, a lump at a time, for weight as they collect it in basket headloads for transport to their furnaces. In other situations they mine to shallow depths for rich and easily smelted ores by a curious system of wells and connecting tunnels somewhat resembling the Persian method of developing underground water supplies.

Excellent hardwood charcoals for smelting purposes are available everywhere, the Sudan being rich in acacias and other suitable species. Charcoals are manufactured by firing stacks of the wood cut in short lengths and banked with earth. Large logs are fired, quenched with water, refired, and again quenched until the wood is exhausted.

During the six months, more or less according to latitude, of the

FIG. 3—Iron mining pits at Dédougou, Haute Volta. Ore in nodules or concretions at 10–12 feet depth.

dry winter season, climatic conditions are especially favorable to iron-smelting operations. Dry mil[1] stalks are available for starting fires, and the heavy labor of transporting ores and fuel is more endurable.

In general the furnaces are built of grouted mud in the form of circular towers, eight to twenty feet high, and five to eight feet in greatest diameter. Usually the structure stands at ground level. In certain localities, however, it stands in a pit the sides of which are built up to the top of the tower and the structure roofed over, thus facilitating access to the mouth of the furnace.

The smelters themselves, as observed in French West Africa, are a caste or guild of hereditary workers regarded, apparently, by their fellow tribesmen as magicians or sorcerers by reason of their mysterious skill in extracting iron from stones. This superstition may be encouraged by their practice of working at night.

## METALLURGICAL PRACTICE IN THE HAUTE VOLTA

During nearly a year's residence (1929–1930) at the native village of Dédougou, also a French administration post, in the Haute Volta,

[1] *Mil* is a general term embracing gros-mil (*Sorghum vulgare*) and petit-mil (*Pennisetum spicatum*).

French West Africa, the writer had opportunity to observe native iron smelting and blacksmithing operations, as yet unchanged by European influences. The process may now be described in detail.[2]

### The Ore and the Furnace

Although surface exposures of laterite are near by, the ore used is mined laboriously, evidently because of its superior quality. The mines are located in a shallow

Fig. 4—Iron furnace at Dédougou—subterranean self-draught type. Mil stalks, charcoal, and ore on platform at mouth of furnace.

valley carrying local drainage to the Black Volta River, six miles distant. During the summer rainy season ground-water levels approach the surface, which is covered with a dense growth of grasses. During the ensuing dry winter season the water table sinks to an observed depth of about ten feet. At this depth nodular iron ore brought down in solution by descending meteoric water is deposited in lumps of limonite (bog iron ore) up to as much as football size. The desiccation of overlying soil at this time must be largely due to transpiration of water by the dense cover of grasses which remain green long after the rains cease. Five samples collected from the native ore heaps averaged 49.9 per cent of metallic iron. During the dry season the native miners sink pits to the ore-bearing stratum at or near water level and tunnel from pit to pit in search of lumps of ore. These are passed back to the bottoms of the pits, thence to helpers standing on shelves excavated in the sides of the pits, and by them to the surface.

The Dédougou furnace is a half-underground structure of the type prevalent in the region. It stands in a round pit about five and a half feet deep and large enough for the workmen to circulate about the tower, which is made of grouted clay and is about four and a half feet in diameter at the well buttressed base. The tower tapers up to a height of about eleven feet, being sixteen inches in diameter at the mouth. The pit enclosure is carried up by a wall of slags to the height of the furnace top, and the structure is roofed over at that level with a platform of poles and tamped clay on which charges of ore and charcoal are assembled. With this inclosed construction a minimum of heat is lost from the furnace in operation, although a small

[2] Compare the account of native methods in Sierra Leone by F. Dixey: Primitive Iron-ore Smelting Methods in West Africa, *Mining Mag.*, Vol. 23, 1920, pp. 213–216.—Edit. Note.

hole for ventilation is left in the platform, doubtless as a precaution against the accumulation of furnace gases in the pit. The bed of the furnace is of ashes into which the molten iron falls and solidifies as it is reduced, with slag accumulating in a lake above the very rugged iron button. A trench in front of the furnace receives the run of slag at the end of an operation. Air is admitted to the charge through six *tuyères* (air inlets) inserted through openings evenly spaced about the base of the furnace two feet above floor level. The tuyères are made of wet clay molded

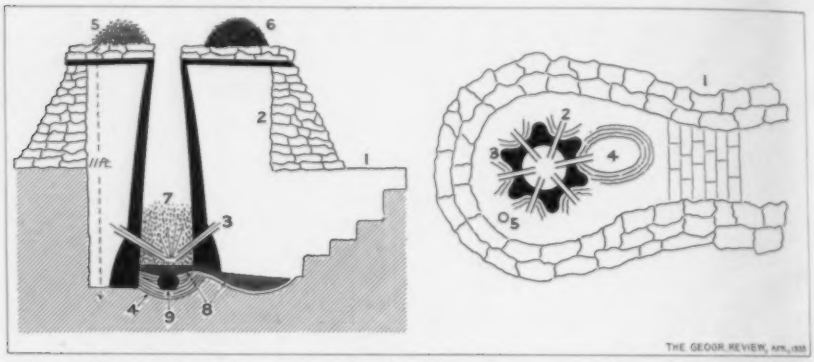


FIG. 5—Side elevation and plan of iron-smelting furnace at Dédougou (for map showing the location of Dédougou see Figure 6 in the author's article "The Desiccation Problem in West Africa: The Capture of the Sourou by the Black Volta," *Geogr. Rev.*, Vol. 22, 1932, pp. 97–106).

Key to side elevation: 1, ground level; 2, slag superstructure; 3, tuyères; 4, ashbed; 5, ore; 6, charcoal; 7, charge; 8, slag; 9, iron button. Key to plan: 1, slag superstructure; 2, tuyères; 3, buttressed base of furnace; 4, slag pit; 5, ventilation.

on straw forms and air-dried. They are about five inches in outside diameter and two feet long and are directed inward and downward, converging at a sharp angle near the bottom of the furnace. No air blast is used, the furnace being self-draught.

## THE SMELTING OPERATION

The preceding run of slag and iron having been dragged out, the ash bed in the bottom of the furnace is rearranged, and the tuyère emplacements are repaired with a mixture of dampened clay and ashes. Dry mil stalks are then inserted at the top of the furnace and ignited, and charcoal is poured upon the densely smoky fire until the stalks are consumed and a clear charcoal fire is established. Then the tuyères are inserted and all openings (except the tuyères) at the base of the furnace are closed with damp earth and ashes, air now being admitted *through* the tuyères.

The charge, meantime, has been prepared by the head smelterman spraying water from his mouth upon the charcoal, which is then mixed in the proportion of six to eight volumes of moistened charcoal to one volume of ore broken to about egg size. The mixed charge is then poured into the open top of the furnace upon the established fire, covering and partially smothering it. Soon the furnace is filled with gases from the smoldering fire, whereupon the smelterman applies a torch to the mouth of the furnace, igniting the gases which strike back with a blue flame to the charge. The draught then quickens, the heat intensifies, and for the time being the furnace is left to itself. During the night the reduced iron trickles down *into* the ash bed where it solidifies as an exceedingly ragged mass containing some adhering slag and charcoal. This ragged condition of the cast is later an advantage to the blacksmiths who can more easily detach pieces from it for fabrication.

Meantime the more fusible slag accumulates in a lake above the iron button.

In the morning the smelters break open the front port of the furnace and run the slag into the trench provided for it where it solidifies and from which it is dragged away when it has partly cooled. A port at the back of the furnace is then opened, and the iron button pried loose and pushed out at the front. Finally, the hot button is cooled with water and cleaned from adhering ash and charcoal. The iron is now a commercial article and may be carried as a headload to distant villages.

TABLE I—PARTIAL ANALYSES OF SAMPLES OF ORE, SLAG, AND IRON FROM DÉDOUGOU

| | ORE | SLAG* | CRUDE IRON |
|---|---|---|---|
| Water at red heat | 12.65% | ..... | ..... |
| Iron as ferric oxide ($Fe_2O_3$) | 73.79 | ..... | ..... |
| Iron, metal | 51.65 | 37.23% | 92.8–96.11% |
| Silica ($SiO_2$) | 12.18 | 32.59 | ..... |
| Titanium dioxide ($TiO_2$) | .32 | ..... | .33 |
| Lime (CaO) | .08† | ..... | ..... |
| Magnesia (MgO) | .39† | ..... | ..... |
| Phosphoric acid ($P_2O_5$) | .50 | .43 | .04§ |
| Residues undetermined | .89 | ..... | ..... |
| Combustibles (charcoal) | ..... | ..... | .33–.30 |
| Insolubles (slag) | ..... | ..... | 3.23–2.38 |

*Containing metallic iron. †Not pure. §As phosphorus (P).

NOTE—The blue flame seen when the furnace gases are ignited indicates the presence of carbon monoxide, resulting in part from the smothered charcoal fire and in part from the reaction between burning charcoal and moisture in the ore and the charcoal (water gas). These resulting gases, carbon monoxide and hydrogen, attack the ore and yield metallic iron.

The loss of iron in the slag is very great because of the lack of lime to combine with silica and other constituents of the ore. The slag adhering to the crude iron is nearly all worked out by the smiths who produce, finally, a very pure grade of wrought iron.

The time observed for a completed smelting operation was from 5.30 p. m. to 8.30 a. m. next morning, and the mass of iron obtained was estimated at about 90 pounds.

The smiths now take over the crude iron, detach pieces, heat them in charcoal fires air-blasted with the native duplex goatskin bellows, work out the slag and the charcoal, and finally produce very pure wrought iron which they shape into the many implements peculiar to native industries.

It is interesting to observe in this remote locality the concentration by natural and human agencies of small amounts of combined iron in ordinary soils to the nearly pure metal. Following are observations worked out by the writer:

| | *Percentage of Iron* |
|---|---|
| 1. Surface soils of the region | 1.52 |
| 2. Subsoils 3 feet below the surface | 1.87 |
| 3. Deep soils from native mines at Dédougou | 22.0 |
| 4. Nodular iron ore 10 to 12 feet deep at Dédougou | 43.6 to 55.2 |
| 5. Crude iron from furnaces at Dédougou | 92.8 to 96.1 |
| 6. Wrought iron from a native forge at Dédougou | 99.1 |

## AGE OF NATIVE SMELTING INDUSTRY

Interesting also is the question of the antiquity of these native arts of iron working. Certainly they are very old. The wide distribu-

tion of primitive furnaces in Africa today, the discovery of prehistoric furnaces in Rhodesia,[3] the presence of slag far to the north towards the Sahara in regions now uninhabited, and the isolation until recently of the negroid peoples all point towards an African origin of iron smelting and manufacture. From interior Africa the ancient slave trade supplying Egypt[4] and the Near East and, from Carthaginian times, crossing the Sahara to the Mediterranean and to Europe may have carried with it a knowledge of iron smelting along with occasional skilled slaves who introduced the art where necessary materials were available.

While the *development* of iron industries[5] was most active about the eastern end of the Mediterranean to meet the needs of warlike peoples for weapons, the *discovery*, or one discovery, of iron smelting may have taken place in negroid Africa.[6]

No one who has watched the careful routine of a native smelter working in remote isolation, totally without metallurgical knowledge and guided only by the empirical experience of uncounted generations of his ancestors, can doubt the antiquity of his art. The slave trade, which has drawn upon negroid populations from remote times, offers an explanation of how a working knowledge of this art may have been carried to other peoples.

## Boat Carpentry

A selection of native industries dependent upon the use of native tools will now be described.

Native canoes, or pirogues, are everywhere used on the rivers and lakes of interior Africa for commerce, fishing, and travel. Their construction varies with the materials available. In forested country where large trees are at hand canoes are dug out of single logs. In the region of small or crooked timbers a canoe is made of adze-hewn boards accurately rabbeted together. Still farther north, where only scrubby palms can be found, native boats are a patchwork of small pieces of wood painstakingly assembled. The tools used are a light

[3] The Mumbwa cavern discovery in Northern Rhodesia is of particular interest. Here buried under several strata of deposits containing stone implements were found the remains of an ancient iron-working industry—furnace and slag. The age of the furnace deposit "may be regarded reasonably as at least 2000, and possibly 4000, years B. C." (Raymond A. Dart and Nino del Grande: The Ancient Iron-Smelting Cavern at Mumbwa, *Trans. Royal Soc. of South Africa*, Vol. 19, 1931, pp. 379–427).

[4] The Egyptian monuments contain frequent representations of files of captives, both Asiatics and negroes. We read also of slaves sent as tribute from Ethiopia (J. K. Ingram: A History of Slavery and Serfdom, London, 1895).

[5] Especially by the Hittites (Hittite Empire, 1450–1200 B. C.) who were the "earliest distributors of iron when it began to displace bronze" (J. H. Breasted: Ancient Times, Boston, 1914, p. 239).

[6] In a letter to the editor Dr. H. J. Fleure states his conclusion "that it was not long before 1300 B.C. that, in the Hittite country, the working of iron was developed. There may have been some utilization of meteoric iron in one or two places before that, but nothing more. The story of ancient workings in Northern Rhodesia is almost certainly as misconstrued as that of the 'Bronze Age' at Zimbabwe."—Edit. Note.

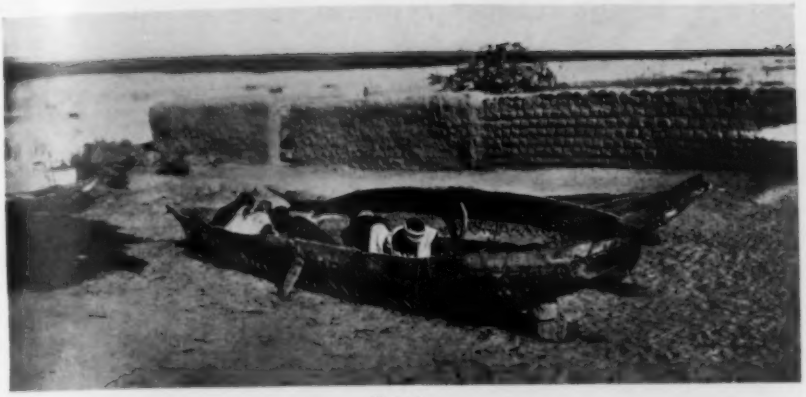

FIG. 6

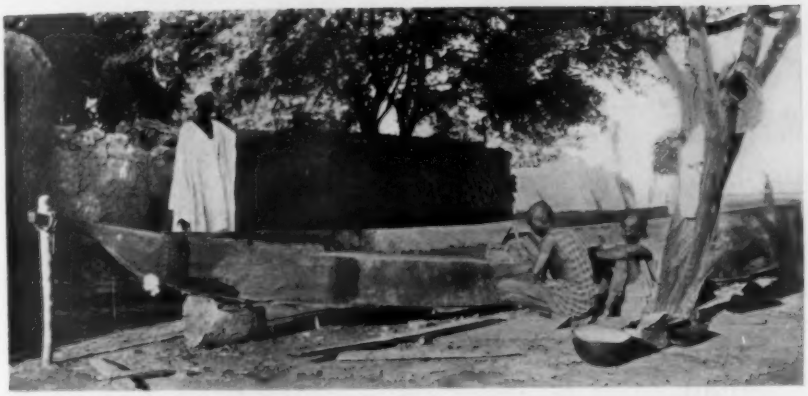

FIG. 7

FIG. 8

FIG. 6—Patchwork construction of pirogues in region where only small timber is available. Gao on the Niger.

FIG. 7—Pirogue builder at work on half of a great canoe. Adze in hand he is rabbeting a plank into place. Diafarabé, French Sudan.

FIG. 8—En route on the Niger with cook, boy, and ten laptots.

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adze tanged into the knob end of a wooden handle, a small iron hammer similarly handled, sharp iron punches for hot-boring nail holes in hard wood, and flat-headed nails of a peculiar pattern, adapted, apparently, to water-tight construction.

The largest canoes, calling for much skill in piece-work construc-

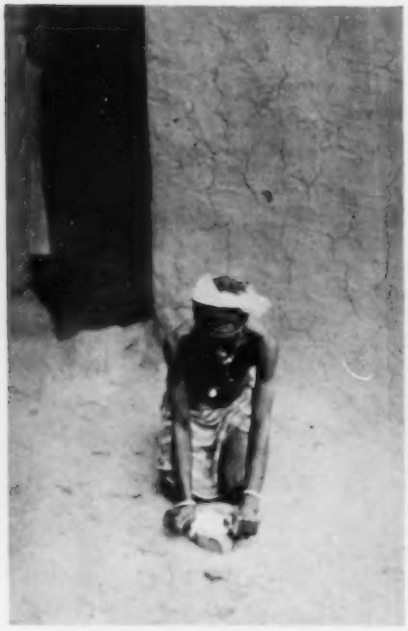

FIG. 9

FIG. 10

FIG. 9—Native method of ginning cotton with a fusiform iron spindle on a flat stone. Banankoro, French Sudan.

FIG. 10—Spinning cotton—showing carded fiber (left hand), whirling spindle (right hand), and ball of finished yarn.

tion may be 60 feet in length and of six tons capacity. The writer's traveling pirogue for voyages on the Niger River was 50 feet in length and pointed fore and aft, 55 inches wide amidships, and 26 inches deep; it was flat-bottomed and had two arched awnings fore and aft made of withes and matting to protect cargo and passengers. The crew of eight men propelled the craft with poles in shallows and with paddles in deep water.

The boat builder works, usually, under an open shed, with an assistant to heat and pass punches when required for nailing operations. Rough planks—*cailcédrat* (a species of mahogany) preferred—adze-hewn from large logs or salvaged from dismantled boats are shaped, rabbeted or beveled, and fitted together to form the two halves of the boat separately. Water-tightness is secured by strips of cloth laid in the joints, which are then snugly nailed together. Nail holes are first burned into the hard wood with red-hot punches, and

the soft iron nails are then hammered into place with the thin flat heads bent over to seal the openings. The two halves of the canoe being completed, they are blocked into position and laced together through eyelets with native-grown hemp cord, which is also used as calking to stop leaks that may appear in the construction. Although

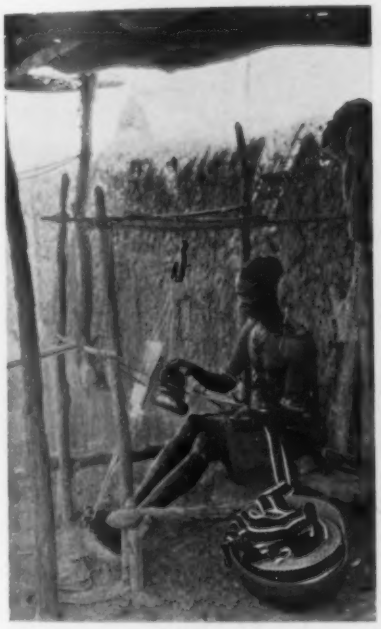

FIG. 11

FIG. 12

FIG. 11—Weaver at work with native loom. Finished strip of cloth in calabash.
FIG. 12—Two women wearing skirts of native batik cotton cloth. Near Molodo, north of the Niger.

the fitting is done entirely by eye these canoes are quite water-tight and show artistic appreciation of form as well as skill in construction. They are essential to native commerce and travel and to the fishing industries in African lakes and rivers. In the days of intertribal warfare the great war canoes carried thirty or forty men.

## COTTON CULTIVATION AND MANUFACTURE

From ancient times cotton has been grown and manufactured in interior Africa. The native *daba*, or iron hoe, is at the foundation of cotton culture. The daba is, usually, a triangular piece of native iron with either a point or a flat edge towards the ground and a tang that is wedged or looped into the knob end of a wooden handle. The daba is a crude and inefficient tool, but seems adapted to native physique and mentality, for it is difficult to persuade the native to abandon it for European tools. With it, however, he manages to break

small areas of ground and cultivate cotton enough to meet his needs for clothing in a tropical country. In this we see a nice adjustment between limited demand and equally limited means of satisfying it. Passing over the details of native cotton cultivation, which would require many pages, various manufacturing operations may be described at some length.

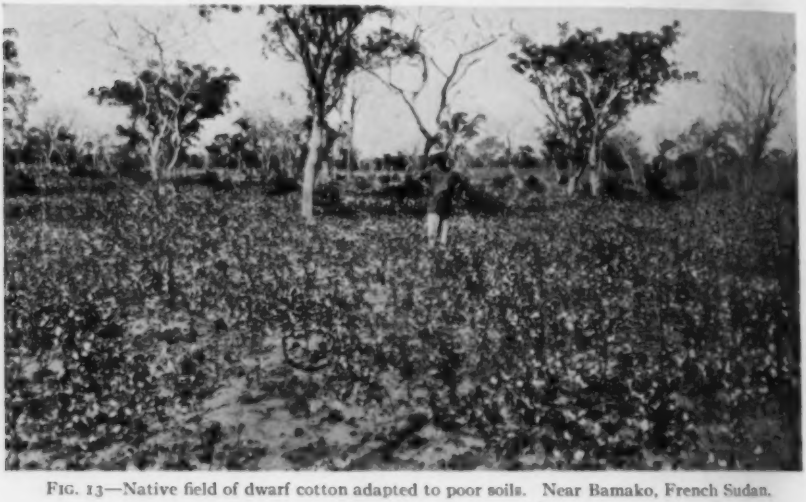

FIG. 13—Native field of dwarf cotton adapted to poor soils. Near Bamako, French Sudan.

The manufacturing operations are divided among several groups of workers—men and women—whose coöperation is required for the production, finally, of cotton cloth. It is man's work to clear and break ground, to sow and cultivate the crop. Women and children, mainly, pick the ripe cotton. Ginning of the seed cotton is done by women with an apparatus consisting of a flat stone about a foot long and a fusiform iron spindle twelve to fourteen inches long. A few locks of seed cotton being fluffed with the fingers and placed on the stone, the spindle is rolled against them, catching the fiber and pushing the seed out before it. This is, in principle, an elementary form of the roller gin.

The ginned fiber was carded, originally, with the spiny seed pod of a native plant; but this crude appliance is now everywhere replaced by wire cards from traders' stores. Carding is woman's work, as is also spinning, the next operation. The spindle used is a hardwood needle ten inches long weighted near its lower end with an ornamented ball of baked clay about an inch in diameter. The weighted spindle, with a flip of thumb and finger, spins like a top on a bit of hide or leather lubricated with talc-like powdered fresh-water oyster shells. The whirling spindle is held upright by the carded roll of cotton fiber fed on and twisted into compact thread which is spooled onto the needle as fast as completed. The finished product is balled, skeined, and, when required, dyed in preparation for the weavers.

A picturesque feature common to native villages is the skeining operation. The yarn is first wound on a wooden wheel about 16 inches in diameter, the projecting loose axle of which is held in the hand. From this wheel on sunny days the women loop the yarn to and fro over pegs thrust at desired distances apart in the ground or in the mud walls of their houses. The threads in a skein are counted according to the requirements of the weaver.

Dyeing and weaving are done by the men, equally skilful in their departments

of manufacture. Native-grown indigo, the prepared leaves being available in the markets, is used to produce various shades of blue in the ill-smelling dye pots of the village. A red dye is used also. This is said to be an alcoholic (native beer) extraction of discolored leaf bases of mil plants caused by attacks of plant lice. Native dyes, however, are rapidly being displaced by imported European colors.

White and colored yarns are woven into narrow strips, patterned or of solid color, which, finally, are sewn edge to edge to form squares of cloth from which native

FIG. 14—Native dry farmer cultivating between young calabash plants to conserve moisture through the dry season. Near M'Pésoba, French Sudan.

garments are made. The native loom consists of a bamboo grating through which the warp threads of the cloth are passed; a foot-power harness for reversing the positions of the two sets of warp threads; and bobbins, each one carrying a desired color or quality of yarn across the warp to form the weft of the fabric. The apparatus is suspended from a rude framework of poles behind which sits the weaver, bobbin in hand and the two slings controlling the reversing harness firmly held between his great and second toes.

In operation the skein of warp is deposited in a weighted drag and stretched out in front of the loom. The threads, having been counted and the colors arranged, are separated into two sets, each set being passed through its half of the reversing apparatus, then through the grating, in front of which the bobbin passes back and forth from hand to hand as positions of the two sets of warp threads are reversed by foot power. From time to time the weft is packed by pulling the bamboo grating against it. The finished cloth is then rolled over a bar adjusted against the weaver's stomach and dropped into a basket on the ground. Music, so necessary to native mentality, is afforded by the squeaking of the apparatus in operation.

With this primitive apparatus and materials coarse but durable fabrics are made in considerable variety of pattern and texture; but production is slow, and native goods are being replaced rapidly by cheaper European fabrics.

### A Unique Native Batik

The successive processes of ginning, carding, spinning, dyeing, and weaving require much skill on the part of the operators, but surpassing them all in technique is the work of the batik makers who, in the village of Molodo, north of the middle Niger, decorate cotton cloth with the crudest of tools and materials. This artistic

FIG. 15—Calabash field showing crop grown by dry-farming methods without rainfall. The large fruit in foreground measures 62 centimeters (2 feet) in diameter. M'Pésoba, French Sudan.

effort is due to the women, and the process takes place in several stages, about as follows:[7]

First, a loin cloth of fine white cotton about three by four feet square is washed in alkaline water leached from ashes to free it from grease and dirt in preparation for reception of color, then dyed yellow in an infusion of *kalama* (probably bark or leaves of an acacia), and impregnated with tannin associated with the dye. The prepared cloth is stretched over an inverted calabash, and designs in melted beeswax are painted upon it with a wedge-shaped iron stylus so designed as to contain and deliver the melted wax upon the cloth (a primitive fountain pen!). A stinking blue mud from a source near Molodo is now spread upon the waxed cloth. The tannin in the kalama dye and the ferrous iron (reduced by organic matter) in the mud react to form ink, which dyes the cloth black except where it is protected by the wax. Finally the mud is washed off and the wax partially scraped away with the

[7] Conversations with M. Costes, French agricultural engineer, familiar with the locality.

FIG. 16—Preparing calabashes for market—bisecting and cleaning them. Niédougou, French Sudan.

FIG. 17—En route to market with the finished product.

finger nails, leaving a design which, after washing, appears white on a bluish-black background. The design shows through faintly on the other side of the cloth, which is of a soft gray color. Ordinarily the women who are so fortunate as to possess this coveted garment wear it wrong side out but on market days and other state occasions expose the right side to public gaze.

So far as the writer is aware this interesting form of batik is made only at the isolated village of Molodo. It is difficult to imagine how knowledge of the art should have penetrated to this remote region and there have been adapted to local materials by these ignorant villagers. As in the case of iron smelting the question arises whether knowledge of the process may not be relict from an ancient semi-civilization long since decadent from undetermined causes.

Native cotton manufacture is manifestly a highly organized group of industries. Cotton cultivation, picking, ginning, carding, spinning, skeining, dyeing, weaving, and ornamentation are each of them in

FIG. 18—The calabash market. Ségou, French Sudan.

the hands of specialists—men and women who must coöperate to complete the manufacture of cloth. It is not difficult, therefore, to see why this organization failed to cross the Atlantic with the slave trade, for the slaver, by purchase or capture, made arbitrary selections of individuals from various tribes and localities. In Haiti, for instance, which has a population largely derived from cotton-growing sections of West Africa, the writer has seen no homemade fabric approaching in quality or method of manufacture the cloths above described.

## The Calabash Industry

In a region lacking rainfall for five to seven months each year it is not surprising to find dry-farming methods in use by some of the agricultural tribes favorably located with reference to soils and rainfall. In certain localities manioc, melons, and especially calabashes are important dry-farmed crops. The calabash, a species of gourd, is the main source of native utensils and containers of many kinds and for the manufacture of various useful articles. By long-continued selection several varieties of calabashes have been developed, and favorably situated villages specialize in raising them for the fabrication of such articles as handled drinking cups; measures of special sizes for the marketing of milk, native beer, rice, mil, baobab flour, etc.; water jugs and bottles; and large containers for the carriage of headloads of produce.

Calabash cultivation requires deep loam soils sufficiently retentive of moisture to carry the crop to maturity without rainfall. Native cultivators are skillful in selecting suitable locations and at the end of the rainy season, usually September, begin by clearing with hoes the dense growth of rainy-season grasses from circles of soil three to four meters apart. Without clearing the whole area at once they dig the circles and excavate shallow basins in their centers in which they plant seed down to moisture. Germination now occurs before the surface soil becomes too dry. Planting completed, the grassy areas between circles are cleared and dug by daba to form a deep surface mulch which restricts evaporation of soil moisture. The young plants are watchfully tended, thinned to the strongest in each hill, and sprinkled with ashes to keep leaf-eating insects away.

With deep root systems established and moisture conserved by the soil mulch the plants grow rapidly, and the vines spread out over the spaces between hills. At blooming time, when large calabashes are desired, all blooms but one are pinched off each vine so that the whole energy of the plant is thrown into a single fruit. With only the cultivation necessary to keep down weeds and without rainfall the crop is matured and harvested in March. By this procedure immense globular fruits up to two feet in diameter are produced.

FIG. 19

FIG. 20

FIG. 21

FIG. 19—Rice—a late variety, inundated to a slight depth only, with water from the Niger flood (background). Diafarabé, French Sudan.

FIG. 20—Making a rice bin of grouted mud. The rock foundation prevents termites from invading the bin. Ansongo, on the Niger.

FIG. 21—Rice—a deep-water variety, being harvested from pirogues in about seven feet of water. Gao, on the Niger.

After the harvest the manufacture of containers begins. The great fruits are first cut in two with long ragged-edged knives (crude saws) by special workmen. The pithy interiors are then removed by other workmen, and the empty shells are scraped, dried, and made ready for market. Headloads of the finished product are carried long distances to regions less favored by soil and climate for this culture. Nowhere in civilized agriculture has the writer seen greater skill employed or more spectacular results obtained than by these self-taught dry farmers of interior Africa.

## Rice Cultivation

Equally astonishing are the results obtained by the flood-plain farmers of the Niger River. Rice is the crop grown, native varieties having been developed to fit various sets of conditions. In brief, the rainy season begins in May or June according to locality, in advance of the annual flood, which is fed from the distant Fouta Djallon Mountains near the west coast.

The natives dig their fields in the flood plain adjoining the river and sow their rice when the rains begin. The plants are therefore up well in advance of the slowly rising flood which inundates the fields of young rice. The varieties grown have hollow buoyant stems which elongate and float to the surface as the flood rises, to a depth noted at Gao on the lower Niger of as much as seven feet. The developing crop is thus kept above water and when ripe is harvested from boats; the grain-laden straw is taken to shore, dried, and threshed; the paddy husked by being pounded in wooden mortars and winnowed in the wind. The cleaned rice is then ready for consumption, for storage, or for commerce.

Other industries that have been developed in detail are fishing by net, hook, trap, and spear; the manufacture of *beurre de karité* (shea butter) from the seeds of *Butyrospermum parkii;* the molding and burning of excellent pottery; the brewing of beers from fruits and grains; the making of soap; the culture of many staple crops with rotations and the application of manures; and a fairly well balanced and appetizing cookery.

## A Complex Semicivilization

The casual traveler passing by the squalid mud or wattlework villages of these African peoples is likely to underestimate them; but more intimate observation reveals a complex semicivilization. Lacking a script no records are available before Moslem penetration into the interior a few centuries ago. Immense distances and a prevailing condition of intertribal warfare long retarded the penetration of outside influences. Such simple devices as the sail for navigation

and the wheel for land transport remained unknown until introduced by Europeans within recent years. Native arts and crafts, therefore, admirably adapted to materials and to natural conditions locally available are certainly in large part indigenous and of ancient origin.

Proficiency in these arts and crafts, furthermore, has prepared the native mind for rapid progress under European tutelage. With instruction excellent blacksmiths, carpenters, cabinetmakers, machinists, masons, and chauffeurs are developed from raw negro material. The native, also, is a good linguist and quick to acquire working knowledge of European languages, business methods, professional occupations, and political organization—in brief, his brain is not that of an elementary savage but seems in some measure to have been prepared for cultivation and fruitful returns.

Whether his ancient semicivilization is relict from some Eden of Pleistocene time, when the Sahara was a grassy plain and its central highlands were the sources of great rivers, or whether it represents a slow emergence from stark savagery is a matter for interesting speculation.

# CLIMATIC AND PHYSIOGRAPHIC NOTES ON FRENCH GUINEA

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## I. Physiographic Features on the New Contour Map

IN earlier journeys in the French Sudan I traveled along the Niger bend; and in the course of a recent journey I have seen the colonies of Senegal, French Guinea, Upper Niger, and the Ivory Coast. So this article is not altogether an arm-chair study. It could, however, not have been made without the fine contoured map of French Guinea on a scale of 1 : 200,000 recently become available.[1] Here for the first time is represented the topography of the massif known as Fouta Djallon, and truly revealing is the picture. Not only does it suggest an unsuspected structure to which all unconsciously the life of the colony is adjusted, but it sets up a train of speculation on that perennially interesting topic—climatic change; for French Guinea, well watered as it is today, yet lies not so far from the southern margin of the Sahara.

### Fouta Djallon

West Africa, as a whole, must be counted a flat country. Its high relief is massed in the south towards the Gulf of Guinea, where a belt of rugged country with summits reaching 1400 to 1500 meters constitutes the hinterland not only of French Guinea but of the English colony of Sierra Leone and of Liberia. Absurdly enough there is no common name for this upland belt, well marked unit as it is. For convenience it will here be spoken of as the Guinea Chain. The western part in French territory is Fouta Djallon, the source of the Senegal.[2] A glance at the map shows that this massif is cut in two by a valley running from north to south. The valley is broad and deep: its breadth 10 to 20 or more kilometers; its floor scarcely reaching an elevation of 300 meters, while the plateau blocks that it separates rise to altitudes of 1000 to 1200 meters, in places to 1400 meters. Now this valley has seemingly escaped notice heretofore,

[1] Service géographique de l'Afrique Occidentale Française. Map in 9 sheets, scale 1 : 200,000; contour interval 50 meters. Compare Édouard de Martonne: La cartographie à l'exposition coloniale de Vincennes, *Ann. de Géogr.*, Vol. 40, 1931, pp. 449–478.

[2] On the central part see Frank Dixey: The Physiography of Sierra Leone, *Geogr. Journ.*, Vol. 60, 1922, pp. 41–65. Dr. Dixey's analysis is penetrating, though the map accompanying his paper gives no representation of the topography.

though such a feature naturally has important practical consequences. For example, the banana plantations, the hope of the colony, are at Kindia, 120 kilometers from Conakry, the port of shipment. Why this distance, so unfavorable for the shipping of fruit? Kindia is the point where the railway crosses the central valley. There and not elsewhere do the planters find plains with a deep arable soil. I have searched the literature diligently but in vain for any reference to this valley which is the key to the topography of Fouta Djallon.

What then is the Kindia Valley? Is it a rift valley? Such a hypothesis is not in accordance with the map. The sides are unsymmetrical—an abrupt scarp on the west, a long gradual slope to the east. It is a product of fluvial erosion of the category known as a cuesta. This is certainly a discovery, and I think the map establishes it without further argument. But let us look a little closer. The Guinea Chain as a whole is an elevated ribbon of old peneplain, of Cambrian or pre-Cambrian age perhaps, certainly pre-Silurian. In Sierra Leone and Nigeria, where crystalline rocks—granite, gneiss, quartzite—are exposed, it can be observed directly. In Fouta Djallon the old peneplain is only seen exceptionally, for it is buried under a practically horizontal red sandstone. The sandstone can be dated approximately by the intercalations of schists containing pre-Devonian fossils.[3] These schists have been encountered in wells at Télimélé, and we may suppose that they occur at the base of the cuesta as the less resistant layers that have determined its erosion. This hypothesis, if verified, will have an interest transcending the limits of the local study of the Fouta Djallon. The intercalation of fossiliferous schists between upper and lower sandstones giving rise to a cuesta is exactly the structure of the Tassilis, to the north of the Ahaggar in the Algerian Sahara (see Fig. 3, after Kilian,[4] whose work has been confirmed by the Olufssen expedition). Tibesti also exhibits the same structure.[5] An identity of structure between these widely separated areas would prove of extraordinary interest in the geological history of Africa. To verify the hypothesis the fossiliferous schists must be sought the length of the cuesta. It is an instance of the topographic map suggesting to the geologist a direction in which to pursue his researches. And it is a case in which the writer regrets once again that his legs are sixty-eight years old.

[3] *Monograptus priodon* of Gothlandien (Silurian), Ordovician, or perhaps even Cambrian age. The schists are called "pélites" on Henry Hubert's map: État actuel de nos connaissances sur la géologie de l'Afrique occidentale, 2nd edit., Paris, 1919, scale 1 : 5,000,000. See also Joseph H. Sinclair: Sur l'âge des grès de la Guinée française, *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Vol. 166, 1918, March 11, p. 417.

[4] Conrad Kilian: Au Hoggar, Soc. d'Éditions Géogr., Marit. et Colon., Paris, 1925, opp. p. 66. See also the map at the end of the volume.

[5] Reported by the Dalloni expedition of 1930–1931, results in course of publication (see G. Dalloni: Une mission scientifique au Tibesti, *Comptes Rendus de l'Acad. des Sci. [de Paris]*, Vol. 193, No. 17, 1931, pp. 720–723).

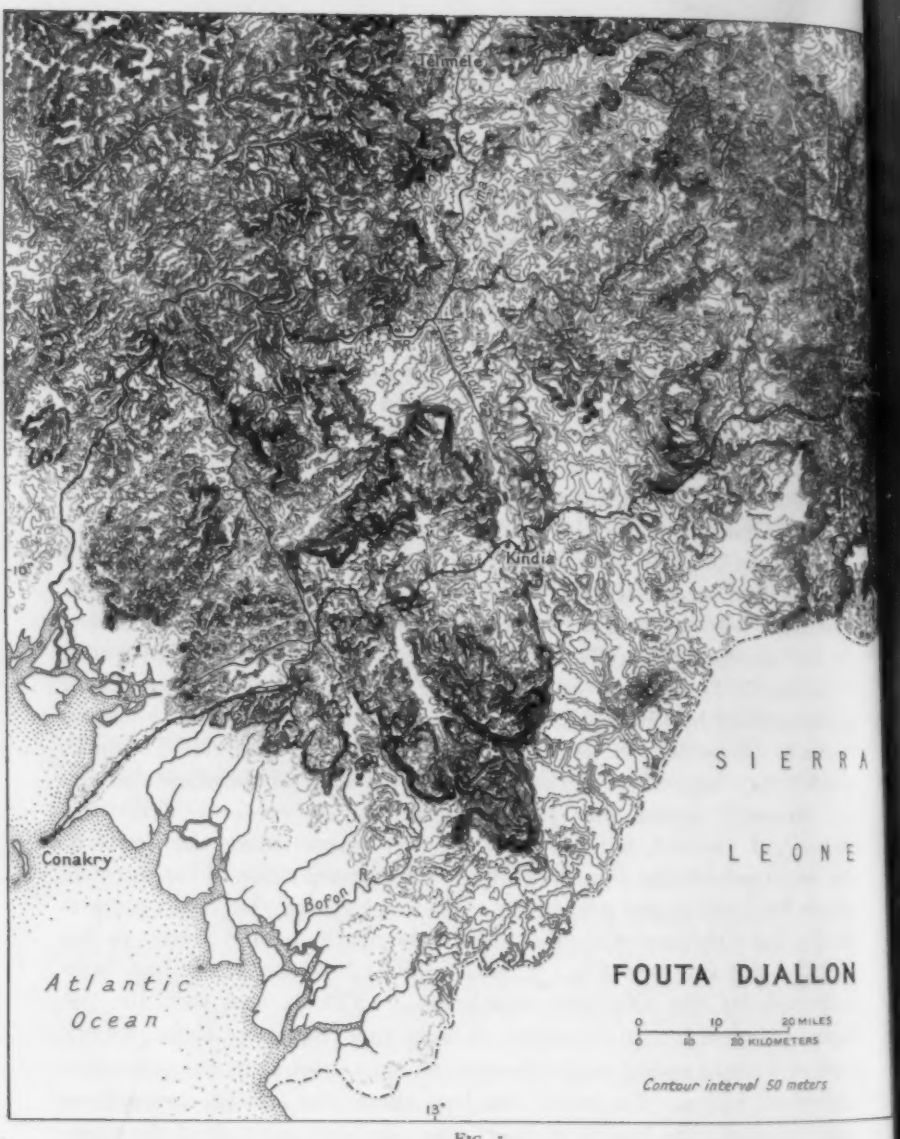


FIG. 1

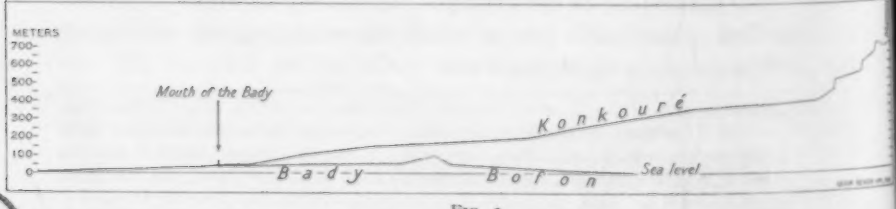


FIG. 2

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FIG. 1—Reduction (1 : 1,500,000) of Fouta Djallon from hypsometric sheets of the map of French Guinea on the scale of 1 : 200,000. The sheets are those for Conakry, Siéroumba, Télimélé, and Kindia.

FIG. 2—Stream profiles from Fouta Djallon—Konkouré and its tributary the Bady and the Bofon. The vertical scale is forty times the horizontal scale.

Until further information is forthcoming we must content ourselves with noting that the Fouta Djallon is a cuesta. That alone is an interesting novelty; but it is not the only revelation on the map.

## Stream Profiles

The cuesta is trenched, about in its center, by the Konkouré, the largest river of Fouta Djallon. It rises at Mamou in a gap in the eastern terminal scarp of the sandstone plateaus and empties into the Gulf of Guinea, west of Conakry, after crossing in serpentine fashion the entire width of Fouta Djallon from east to west. At the point where the Konkouré flows transversely across the great central valley and trenches the cuesta it receives a right-hand tributary, the Kakrima coming from Télimélé, and a left-bank tributary, the Mayonkouré coming from Kindia. One might suppose that these streams were the agents that carved the cuesta.

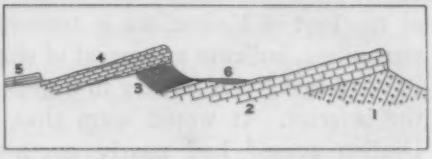


Fig. 3—This diagrammatic section across the Tassilis, north of the Ahaggar (after Conrad Kilian: Au Hoggar, Paris, 1925, p. 66) might be regarded as a diagrammatic section of Fouta Djallon. Numbers have reference: 1, crystalline schists; 2, lower sandstones (Inner Tassilis); 3, graptolite schists; 4, upper sandstones (Outer Tassilis); 5, fossiliferous Devonian.

But with the topographic map available, the stream profile of the Konkouré can be constructed (Fig. 2). This profile bespeaks a very young river: it has not had time to grade its valley, not even, speaking precisely, to excavate it. In the lower course the profile is rectilinear rather than concave, in some sections even slightly convex. In the upper course the profile is toothed. The river descends abrupt slopes which it has only just begun to modify. Even its watershed is not sharply differentiated. At Conakry the photographs of Fouta Djallon sold to tourists are those of cascades and rapids. So young a river cannot be the agent answerable for such a feature as the great cuesta. A river that had had time to carve the cuesta would have had time to carve out for itself a broad graded valley.

But lack of time is not the embarrassment. As far as one can judge, the Fouta Djallon sandstone has been land since Silurian times, a formidable length of time for stream sculpture. If these rivers are not answerable, where shall we look? We find a hint in a left-bank tributary of the Lower Konkouré, the Bady, whose profile is shown with that of the Konkouré in Figure 2. The entire profile of the Bady lies at a lower level than that of the Konkouré; i.e. the valley of this small tributary is deeper and nearer grade than that of the arterial stream. Examination of the map shows that the Bady flows through a magnificent valley, remarkably straight, broad, and deep, a valley

of which it is evidently innocent and to which it does not properly belong. The Bady flows south-to-north towards the Konkouré, while a small stream, the Bofon, utilizing the same valley, flows in the opposite direction to the sea; and this it would seem is the rational course. To the south of the Conakry region the sandstone plateaus of Fouta Djallon terminate seaward in a steep scarp, another cuesta, if you like, but a cuesta due in part to marine erosion.[6]

This scarp is broken throughout its entire length by gorges that cut it from summit to base; that utilized by the Conakry Railroad at the foot of Kakoulima is 1000 meters deep. These gorges, today streamless, indicate a reversal of slope. They must have been carved by vanished rivers flowing in a general north-to-south direction from the interior. It would seem that at some distant time the Fouta Djallon massif had nearly north-south drainage, almost at right angles to the present system. And that presumably was the time when the essential features of the great Télimélé-Kindia cuesta were fashioned.

### Features Suggesting a Shift of Climatic Zones[7]

Conakry has a rainfall of four or five meters (150 to 200 inches) a year; in the interior of Fouta Djallon the amount is somewhat less but probably two meters (80 inches) at a minimum.[8] The distribution is seasonal; there is a long dry period, the end of which finds the country burnt up, bare, and pulverized—a condition evidently favorable to the progress of erosion by the torrential downpours of the equatorial rains. And in such a country the rivers have not had time to carve their valleys? The epeirogenic movement that uplifted the Guinea Chain and reversed the slope of the rivers unquestionably is relatively recent, geologically speaking, but it is not easy to assign an exact date. Eruptive rocks have an important place in the Fouta Djallon sandstones; but they are ancient intrusive gabbros and diabases. Hubert, who has given them closest study, believes they are nearly contemporaneous with the sandstone, that is they are pre-Devonian. There are no well preserved remains of Tertiary volcanism here, as there are in Nigeria. In Northern Nigeria Dr. J. D. Falconer attributes the epeirogenic movement to the Neogene. If this date be accepted then throughout the Pliocene and Quaternary the rivers of Fouta Djallon have not had time to carve their valleys? Extraordinary—if climatic conditions have been the same as they are today. But perhaps they have not.

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[6] Cf. Dixey, *op. cit.*

[7] A presentation of Professor Gautier's thesis before the Association de Géographes Français provoked an interesting discussion in which MM. Emmanuel de Martonne, L. Aufrère, and A. Chevalier participated. See *Bull. Assn. de Géographes Français, Nos. 59 and 60*, 1932.—EDIT. NOTE.

[8] Télimélé has 98 inches of rain; Mamou, 94 inches. See Rainfall Chart of West Africa (1:6,336,000), *Year-Book, 1930* (*Bull. No. 23*), Dept. of Agric., Gold Coast.

The sandstone plateaus of Fouta Djallon are broken into innumerable small blocks separated from one another by deep gorges—a kind of topography to which Hobbs has given the name of checkerboard.[9] Checkerboard topography has been found by Hobbs to be best exhibited in regions where fluvial erosion has not had time to efface structural scars—on the Norwegian coast and in the Adirondacks, for instance, regions that during the Quaternary were protected against river erosion by a covering of ice. Fouta Djallon assuredly did not enjoy such a protection. But one can conceive a similar result arising from a climate entirely different from that of the present—a desertic climate. The Sahara is not far distant; its limits have not been fixed through the ages; it has been suggested that in the Quaternary the desert was pushed farther south. Can it have extended to the Gulf of Guinea?

Obviously this is a hazardous hypothesis. But the extreme youth, the infantile character of the stream lines, is an enigma demanding explanation, and it is incomprehensible if the present régime of equatorial rains of two to five meters held sway in the past.

Other indications point in the same direction. There is, for instance, the odd occurrence of an efflorescence of natron in a humid region, Firkissidougou, on the Ivory Coast. And there are the fixed dunes of the colony of Senegal, a great Quaternary erg killed by the rains of today. Going farther afield, there is the case of the Adrar des Iforas with its torrential rains and its lack of valleys,[10] the opposite of conditions in the Ahaggar, where magnificent canyons are now deprived of running water.[11]

## Laterite in Madagascar and West Africa

I am inclined to think that the geographers and geologists of the French and English colonies of West Africa are somewhat out of touch with each other's work; and I must confess that only now have I given close attention to "The Geology and Geography of Northern Nigeria," by J. D. Falconer, a book that appeared in 1911. Nor am I sure that even among my English confrères have Falconer's suggestions met with the attention they deserve, because they must be taken into account with French work. I am deeply indebted to Falconer for his proposal of a solution, or at least a hypothetical solution, of a problem that has long preoccupied me—the problem of laterite.

A residence of seven years in Madagascar familiarized me with

[9] W. H. Hobbs: Repeating Patterns in the Relief and in the Structure of the Land, *Bull. Geol. Soc. of America*, Vol. 22, 1911, pp. 123–176.

[10] E. F. Gautier: À travers le Sahara français: D'In Ouzel au Niger, *La Géographie*, Vol. 15, 1907, pp. 1–28 and 103–120.

[11] *Idem:* The Ahaggar: Heart of the Sahara, *Geogr. Rev.*, Vol. 16, 1926, pp. 378–394.

the laterite of that country. It is a red clay which forms a continuous crust, a dozen or several dozen meters in thickness, covering immense areas. Beyond question it is the result of superficial decomposition of crystalline rocks in place. Note that it is clay. The exploitation of graphite, an industry of great economic importance for Madagascar, rests on the fact that the laterite, the mother rock, breaks up readily under the spade and the graphite can be separated by sluicing.

In my latest journeys I have become acquainted with the laterite of West Africa. It also is a continuous mantle covering immense areas. But it forms a carapace of very hard rock, blackish in color, essentially an iron ore. In Madagascar on the one hand and in West Africa on the other the same name is given to formations that to the layman look entirely different. Observations of this sort, of course, are not new: laterite has long been said to be polymorphous.

But, to be more specific, the laterites of Madagascar and West Africa have been the subject of exhaustive study in field and laboratory by the eminent mineralogist Alfred Lacroix.[12] M. Lacroix notes of course the differences of facies; to the Madagascan form he has given the name lateritic clay, reserving the name laterite for the West African form. But these differences of facies conceal a close similarity of chemical composition. The results of meticulous analysis may be briefly expressed in the conclusion that under the influence of the warm tropical rains crystalline rocks laterize; that is they lose progressively by leaching of their constituent elements until the end product is a hard blackish ferruginous concretion.

The difference between the Malagasy and the Sudanese facies is that the former has reached a less advanced stage of chemical decomposition. So far so good. One cannot question the incomparable authority of M. Lacroix. But there remains a question that the eminent mineralogist cannot answer because he refuses to go beyond the bounds of mineralogy. From the geological point of view how can one explain retardation of evolution on the one hand and its acceleration on the other in the two tropical countries under discussion? Here is where Dr. Falconer comes in.

## The "Drift" of Nigeria

The sixth chapter of Dr. Falconer's excellent book is devoted to superficial accumulations. He describes the occurrence in Northern Nigeria of a

> ferruginous cap or crust, which frequently forms a continuous floor many acres in extent. . . . [This crust presents a] characteristic cellular or vesicular character and hard lustrous surface (p. 199).

[12] Alfred Lacroix: Minéralogie de Madagascar, Paris, 1922; *idem:* Les latérites de la Guinée et les produits d'altération qui leur sont associés, *Nouvelles Archives du Muséum d'Hist. Nat.*, Ser. 5, Vol. 5, 1913, pp. 255–356.

It would be called laterite in the French Sudan; but Falconer avoids the term, using "ironstone" in its place.

M. Chudeau has remarked upon the absence of any deep decomposition of the rocks in situ in the Sahara and Sudan north of lat. 11°, and his remarks may with justice be extended to the greater part of Northern Nigeria (p. 195).

Falconer emphasizes this important negative fact and notes

There are . . . few remaining traces of any earlier weathering of the crystalline and igneous rocks preserved underneath the superficial accumulations. For the most part the latter rest upon smooth and completely unweathered surfaces of rock (p. 203).

The surface ironstone, then, is not the result of a decomposition of the rock in situ. It has a direct relation with the superficial accumulations that Falconer calls the drift.

The original products of decomposition have rarely remained in place but have travelled outwards for a variable distance from the parent rocks and in places accumulated to very considerable depths. This drifted or travelled character of the surface alluvium may be typically observed round the margins of the larger groups of granite hills. The distintegrated debris rapidly accumulated during torrential rains at the mouths of the narrow valleys or at the base of the weathered slopes is gradually broken up and spread out upon the plain during succeeding periods of less intense fluviatile action (p. 195).

It is to this alluvial drift that Northern Nigeria owes its topography, the topography known in physical geography as inselberge landscape—isolated hills and bare surfaces of rock emerging like islands from the detrital plain. The ironstone surface does not appear on the hills which generally exhibit bare and fresh rock surfaces. The ferruginous cap covers the drift of the high plains.

The ferruginous cap has arisen through the cementation of the quartz grains and pebbles into a hard resistant mass by means of hydrated ores of iron originally deposited in the subsoil above ground water level (p. 199). . . . and there can be little doubt that within the Protectorate as a whole, the formation of surface ironstone upon material actually weathered *in situ* is the rarer phenomenon. For the most part the ironstones rest upon and have been formed within drifted and travelled superficial material (p. 205).

How is the concentration of the iron explained? Falconer is less sure. A Frenchman has the advantage of being able to clarify the matter by a familiar example. The banks of ferruginous material may be formed by subsurface evaporation and oxidation after the manner of the *alios* of the Landes. Here, at a little distance from the surface of the sandy cover, is everywhere found a ferruginous crust which has been a serious obstacle to utilization of the land. It is not for me to pass judgment on the absolute correctness of Falconer's observations; but they evidently rest on a profound knowledge of Northern Nigeria, and they do suggest an explanation of the profound difference in facies of the lateritic clay of Madagascar and so pre-

sumably of other tropical lateritic clay, for they are not peculiar to Madagascar, of which I have spoken only because I know it well.

## Inselberge Landscape in West Africa

The inselberge landscape is not peculiar to Northern Nigeria. Dixey speaks of an analogous formation in Sierra Leone.[13] Immedi-

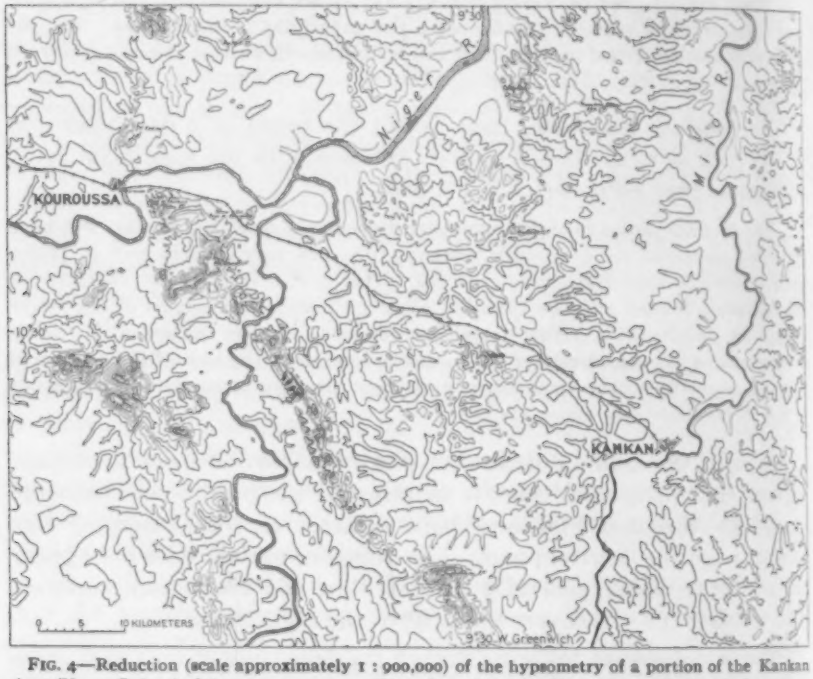


FIG. 4—Reduction (scale approximately 1 : 900,000) of the hypsometry of a portion of the Kankan sheet (Upper Guinea) of the 1 : 200,000 map. The railway line from Kourousa to Kankan is shown.

ately to the north of Sierra Leone and touching the frontier of the English colony we have the three sheets of Dabola, Faranah, and Kankan. They represent Upper Guinea, a high plain, accidented in places and crossed by the two rivers that unite to form the Niger, the Niger proper and the Milo. On the former is the small town of Kourousse; on the Milo, that of Kankan—the respective heads of navigation of their streams and stations on the Conakry-Kankan railroad.

Upper Guinea, then, is evidently not a peneplain but a detrital plain, a "drift" plain in Falconer's terminology, rising out of which are the isolated hills of crystalline schists, which, by definition, constitute the inselberge landscape.

Figure 4, a photographic reduction of the relief of a part of the Kankan sheet, is a graphic illustration of Falconer's interpretation of Northern Nigeria. Note that the distance between Nigeria and

[13] Dixey, *op. cit.*, p. 59.

Upper Guinea is nearly 2000 kilometers. We have no topographic map of the Ivory Coast. But I have traversed it by automobile. As far as can be seen under the cover of the great equatorial forest, which makes observation difficult, it appears that the whole of the territory up to the sea is marked by drift topography and inselberge landscape. The conclusion then is that this topography extends over the whole of West Africa, French and British.

## Former Extension of the Sahara

In seeking a general explanation of his observations Falconer admits, with caution, the possibility of a former extension of the Sahara to the south, it may be in the Quaternary. As has been already pointed out, he recognizes with Chudeau that the absence of deep decomposition of the crystalline rocks is a character that Northern Nigeria and the Sudan share with the Sahara as a whole. He is also struck, like Chudeau, by the occurrence in the present rainy zone of ancient dunes, dead and covered with vegetation.

> . . . the worn and rounded dunes of the dead *erg* of northern Hausaland. The dunes are now grassed over and covered with scattered trees, but their origin is still sufficiently indicated in their composition and general outlines as well as in the characteristic banking of the sand against rocky exposures (p. 214).

He thinks that there was a period of minimum erosion and accumulation during which the surface drift was spread out upon the plains. As a matter of fact, accumulation by drift presupposes a more or less arid climate when the rivers had not the power to carry their alluvium to the sea. This time of minimum erosion immediately preceded the present during which

> in places, successive platforms have been cut in the drift and floored with concretionary ironstone (p. 212). . . . There is little doubt that the formation of the surface ironstones was favoured by the successive occurrence of periods of maximum evaporation, and it is highly probable that these periods assumed at times a typically desert character. . . . One such period at least immediately preceded the present more humid conditions (pp. 213–214).

The "inselberge landscape," to use Falconer's Anglicized form, is a term introduced into scientific literature by Siegfried Passarge after observations made in the Kalahari Desert. The type of topography is widespread through the high plateaus of Algeria and in the entire Sahara. I do not know in what measure physiographers identify it with a desertic climate. I can only say that there is no trace of it in Madagascar, a country of equatorial rains of an intensity comparable with those of present-day West Africa.

Independently of Passarge French geologists had recognized inselberge in the Sahara and had compared them to islands in the Aegean rising from a detrital sea, Falconer's "drift," for which they

had kept the Arab term, *reg*. Falconer only knew the *reg* from the literature, but its identity with the "drift" had not escaped him; he expressly mentions it (p. 226). And certain it is that the hypsometry of the Kankan sheet such as we have reproduced here and the general aspect of the terrain, apart from rivers and vegetation, would equally apply to the Saharan *reg*.

In conclusion we must agree with Falconer's prudent statement, "It is yet premature, however, to attempt any correlation of these deposits with the drift of Northern Nigeria" (p. 226). Any conclusion that claimed to be definitive must be premature. Yet it is permissible to point out the agreement of local studies made by French and English geologists working independently of one another. They all point in the same direction. At a time immediately preceding the present the limits of the Sahara were displaced appreciably towards the south. This is not a hypothesis, but a fact. But what is the significance of the displacement? It is here that hypothesis begins. Has the Sahara at a not far distant time extended to the coast of the Gulf of Guinea, covering the present domain of the equatorial forest? Certainly this is a hypothesis and, if you like, a venturesome hypothesis; yet it seems to accord well with the facts. The geologists who study West Africa should not lose sight of it. It is true, of course, that an opposite situation obtains in East Africa: the present-day glaciers of Kenya, Kilimanjaro, and Ruwenzori exhibit marked retreat as compared with the Quaternary glaciers. But it is not necessary that East and West Africa should have had the same geological past.

# A WORLD MAP OF TIDES

Hubert A. Bauer

[With separate map, Pl. III, facing p. 266]

THE tide as a *geographical* phenomenon has been sadly neglected. And yet, directly or indirectly, there is scarcely any phase of shore life upon which the tide does not leave its mark. As a coagent in the remodeling of shore lines, a provider of food for sessile life forms and therefore a habitat for a limited number of plants and animals, a builder of salt marshes, a locative factor for harbors and ports, a favorable or adverse element in navigation, a molder of certain human traits and habits, the ubiquitous relentless tide, foe and friend to man, builder and destroyer, is surely entitled to serious consideration among the elements of natural environment. Why is the tide commonly treated promiscuously, if not confusingly, with other elements of the hydrosphere, such as waves and ocean currents? Why does the geographical treatise characteristically neither make allowance for nor offer explanation of the tremendous variety of tidal manifestations the world over?

The reasons for this negligent attitude lie primarily in the intricacy of the tidal phenomenon itself, in its still problematic nature as a world phenomenon, and in the inadequacy of its technical presentation. The tidal mathematician, who has developed tidal knowledge, especially prediction, to a degree almost beyond the limits of practical needs, has not taken the initiative in presenting the results in a form immediately utilizable in geographic work. The geographer, on the other hand, has neither the equipment nor the desire to venture into the intricate mathematical and hydrodynamical phases of the subject. In consequence, while geographic tools, particularly maps, have been increasing in number, variety, and quality, there has been available no *geographical* map of the world's tides. Plate III, facing p. 266, is a first effort to meet this deficiency.

## The Technical Basis

Without going into the subject of tide genesis, it is necessary to recall that the tides of the world are subject to the periodicity of the tide-producing forces of moon and sun and therefore undergo manifold periodic changes in intensity while running through certain cycles as conditioned by the motions and changing distances of the three involved bodies. These changes, known as tidal variations,

are neither of great geographic importance, since they are a feature of practically all tides of the world, nor are they susceptible of cartographic expression. Quite otherwise is it with the variations of tides that are a function of the locality at which they occur. A sharp distinction must be made between the oceanic responses to the tide-producing forces, still a matter of speculation, and the well known effects of these responses upon the thousands of limited coastal areas that make up the tidal waters of the world.

While there has been surprising success in coastal tidal research, there still is disagreement among physical oceanographers as to the exact manner in which the local tides should be fitted into a plausible world picture.[1] The two different theories that hold the field are the older progressive-wave theory and the newer stationary-wave theory. However, the problems involved in the altercation are of secondary interest to the geographer. That a place X experiences its highest tides say 2 hours and 36 minutes after the meridian passage of the moon, while a place Y experiences them 4 hours and 43 minutes after this instant is not in itself an important or helpful fact to the geographer. Cotidal maps delineating the progression of tidal disturbance over a limited coastal area hold little immediate practical value for geographic work. On the other hand, there are numerous geographical phenomena recognized as functions of tidal range and of tidal type, both of which are intimately associated with the nature of the locality and furthermore are independent of disputable theory. A tidal world map for geographic purposes must be based on these features.

The numerous existing types of tidal oscillation are conveniently classified into three major types according to the period of oscillation. Thus, a tide with high water occurring approximately every 12 hours is termed a "semidiurnal tide," one with high water every 24 hours is spoken of as a "diurnal tide," while those tides having a higher high water every 12 hours and a lower high water occurring between any two higher high waters, suggesting an interference of two oscillations or waves, are termed "mixed tides." The advantages of this genetic classification of tides have been pointed out by H. A. Marmer.[2]

One important phase of tidal mathematics deals with the harmonic analysis of tides for the sake of exact tidal predictions. Tidal motion being always periodic in character can be regarded as the resultant of a number of simple harmonic motions, the component tides. Each component tide representing a partial producing or modifying force

[1] See H. A. Marmer: On Cotidal Maps, *Geogr. Rev.*, Vol. 18, 1928, pp. 139–143; see also his chapter "Tides and Tidal Currents" pp. 229–309 in "Physics of the Earth—V: Oceanography," *Bull. Natl. Research Council No. 85*, 1932.

[2] H. A. Marmer: On the Classification of Tides, *Journ. Conseil Permanent Internatl. pour l'Exploration de la Mer*, Vol. 7, 1932, pp. 11–24; *idem:* Classification of Tides for the Engineer, *The Military Engineer*, Vol. 23, 1931, pp. 172–175.

is determined by two values, its amplitude, or semirange, and its angular speed per solar hour, known as epoch. The numerical values of amplitude and epoch, the harmonic constants, can be determined for any tidal locality from long-time records of tidal observation; they can, in turn, be used to determine the exact nature of a local tide, particularly its type and its average range. Thus, a certain algebraic function of the amplitudes of the four major harmonic constants is known as the type index. If this index lies between 0.00 and 0.25, the type is semidiurnal; if it lies between 0.25 and 1.25, the type is mixed; if it is greater than 1.25, the type is diurnal.

While all the type indices of the stations listed in Tables I, II, and III have been determined algebraically from harmonic constants,[3] many of the tidal ranges have been obtained from other reliable sources[4] or from first-hand information and only to a small extent from harmonic constants.

## General Interpretation of the Map

Examination of the world maps of distribution of the physical elements, such as winds, climates, ocean currents, that have become indispensable tools of geography reveals a definite regularity or symmetry in the arrangement of the features represented; a regularity that reflects cosmic harmony modified by terrestrial influences. Well marked harmonic laws of distribution are obviously at work in all such distribution maps. A world map of tidal types and tidal ranges, however, reveals nothing of this sort in operation. Latitude, so strong a control in other geographic maps, evidently plays no part at all, although theoretical reasons would seem to demand it. The width of the continental shelf is, in the minds of many writers, the only factor accountable for local differences in tidal range. But this general belief loses some of its apparent weight when faced by the facts presented in a tidal world map; for the broad shelf of the North American Atlantic coast produces tides of but half the range found on the much narrower shelf of the Iberian Peninsula; and under similar shelf conditions Nantucket Shoals has but a 4-foot range, while Quessant in the English Channel has one of 20 feet. Likewise, no positive or close relationship can be discerned between the continental shelf and the type of tide; for the diurnal type, which would seem to be related to regions of broadest shelf, is found on the extremely narrow shelf of southwestern Australia, while the broad shelf from which the British Isles rise produces a purely semidiurnal type.

[3] Most of the data have been adopted from Paul Schureman: A Manual of the Harmonic Analysis and Prediction of Tides, *U. S. Coast and Geodetic Survey Special Publ. No. 98*, Washington, 1924.

[4] Otto Krümmel: Handbuch der Ozeanographie, 2 vols., Stuttgart, 1907, 1911. Rollin A. Harris: Manual of Tides, Part IV A, *U. S. Coast and Geodetic Survey Rept. for the Year ending June 30, 1900*, Washington, 1901, pp. 535–699 (Appendix No. 7). Nathaniel Bowditch: American Practical Navigator, U. S. Hydrographic Office, Washington, 1929.

The comparison between type and range, on the other hand, yields a more definite relationship. It seems that the higher ranges are in general associated with the semidiurnal types, while the low ranges are chiefly a feature of diurnal types; this leaves, of necessity, the intermediate ranges to the mixed type. But even this relation is far too general.

The great advantage of a world map of tidal types and ranges lies, however, less in the possibility of discovering relationships between type and range than of recognizing the hydrodynamical laws that underlie differences in both type and range.

Even the casual observer will at once associate the semidiurnal type of tide with the Atlantic Ocean, both North and South, and the entire Pacific rim with the mixed type of tide. The diurnal type stands out as a feature of the American and Australasian Mediterranean and of similar inclosed seas. The simple conclusion is that the type of tide is related to or rather a function of the type of ocean basin. In fact, the relatively narrow trough of the Atlantic is typically different from the widest of oceanic depressions, the Pacific.

The hydrodynamicist bases his theory of stationary waves entirely on the dimensional differences of the oceanic basins. It must be recalled that it is the period of oscillation—diurnal or semidiurnal or intermediate—that forms the discriminating element in type. Laws of dynamics determine the degree of accordance between the period of an oscillation and that of the producing forces. The nature or rather the dimensions of the oscillating system enter the problem in so far as each body has a free swinging period directly proportional to its length—the length of the pendulum. An oscillating water surface responds more readily to the periodic impulses exerted by moon and sun if its dimensions permit or favor a natural oscillation whose period is equal or nearly so to the period of the impulse. The period of the tide-producing forces is twofold, semidiurnal and diurnal. Hence the Atlantic Ocean with its shorter east-west dimensions will best respond to the shorter semidiurnal impulses; or—as an important alternative—forced oscillation will be set up, the period of which is strictly identical with the shortest period of the forces. The Pacific Ocean offers more possibilities in this respect. It is long enough and deep enough to sustain a longer oscillation than one of half a day; in fact, some of its dimensions are in almost ideal accordance with an oscillation of a one-day period and respond readily to the diurnal component of the tide-producing forces. No wonder, then, that in the complex system of oscillations into which an irregular ocean basin such as the Pacific is broken up both periods, the diurnal and the semidiurnal, are reflected. The resultant tidal motion is indeed chiefly an interference of two standing waves, one of 12 hours' and one of 24 hours' period, or, in other words, the mixed type of tide.

If an oceanic area is extremely shallow as compared with the abyssal depth of an adjoining trough, its tidal motion is practically independent of the oscillations that prevail in the adjoining deeper ocean; the tidal period in such an epicontinental sea, which through enclosure by island chains becomes almost epeiric, is then merely controlled by its own length and depth. This is, apparently, the reason why the purely diurnal type of tide seems confined to shallower seas where dimensions are such that the 24-hour period is most favored.

## Additional Hydrodynamic Laws Involved

In order to link the actual coast tides into a general terrestrial pattern, two further considerations are necessary. The lack of definite physical boundaries within the oceans gives rise to numerous interferences of stationary waves, which in turn condition various modifications in tide types from place to place, the gradual transition from one type to another, and finally the occurrence of certain exceptional tidal phenomena. The low tides of the La Plata funnel, the double tides of Southampton Water and of Le Havre, the vanishing tides of Port Townsend,[5] the solar tides of Tahiti,[6] the variable tides of Cristobal[7] are examples of such modifications and exceptions due to wave interferences. In the second instance "where openings occur in the vicinity of an oscillating system, progressive tidal waves are formed which travel up these openings; shoals likewise give rise to progressive waves."[8] It is obvious that the periods of these propagated waves, which are typical of almost all coastal indentations, are exactly those of the stationary waves outside. Frequently, as in the North Sea or in larger sounds, two such progressive waves are being propagated into the locality from different sides and at a certain definite interval. The result is, of course, a local interference, which may produce an extraordinarily high range at one place and a surprisingly small range at another place near by. For instance, the mouth of the Thames has a tidal range of 20 feet, while on the Dutch coast, less than 100 miles away, the range is but 5 feet.

The conception of the oceanic tides as stationary waves serves also as key for the geographic distribution of tidal range. A stationary wave has a neutral line about which the water surface swings. In the case of interferences two or more neutral lines intersect, destroying their neutrality mutually but creating a neutral point or spot about which the surface swings in a more or less circular motion, which Harris described as amphidromic or spokelike. Such nodes or amphi-

[5] H. A. Bauer: Tides of Puget Sound and Adjacent Inland Waters. (In manuscript.)

[6] H. A. Marmer: The Tide, New York, 1926. Krümmel mentions two more cases of solar tides, at Finschhafen, New Guinea, and on the north side of the island Guadalcanar, Solomon Islands.

[7] R. Z. Kirkpatrick: Panama Tidal Differences, *The Military Engineer*, Vol. 24, 1932, pp. 236–237.

[8] Marmer, The Tide.

dromic centers tend to originate near the centers of the larger oceanic areas. Consequently the tidal range of a place will largely be controlled by the distance from the nodal point, where the range is practically zero, and the greatest range is likely to occur at the extreme end of the wave. This extreme end is always somewhere at the

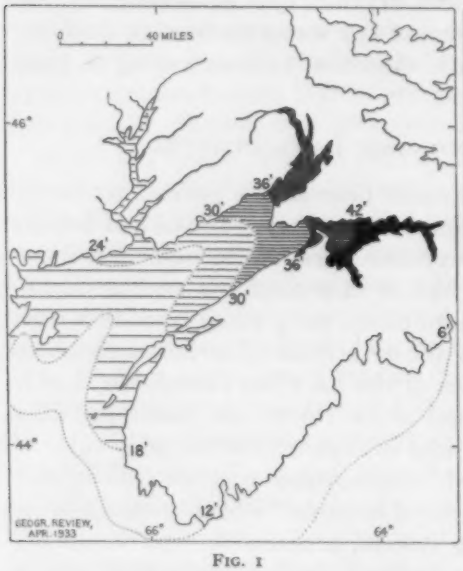


FIG. 1

FIG. 2

FIGS. 1 and 2—Examples of great tidal range. Figure 1, tides of the Bay of Fundy. Figure 2, tides of Gallegos Bay, Patagonia.

coast, where other influences such as the shoaling of the continental shelf, the natural slope of a drowned river bed, or the convergence of the shore line tend to augment the range. The highest tides known, in the innermost Bay of Fundy, in Gallegos Bay, Patagonia, in the Bristol Channel, and in some other less known cases, are a result of the combination of two or more of these causes. If at some places, where suitable natural conditions prevail, the tide fails to reach a correspondingly high range, the reason may again be sought in an interference of two waves or in the meeting of the crest of an incoming wave with the trough of the reflected wave of its predecessor.

## MIXED TIDES AND THEIR DISTRIBUTION

The mixed type of tide, reflecting the largest number of tide-producing components, must be termed the most perfect of all types of tide. It is a type normally expected to exist in those waters that offer the least obstruction to free oscillations of both a 12-hour and a 24-hour period. Practically the entire Pacific Ocean possesses mixed tides: the few exceptions are confined to the southern part of the

Chilean coast, to the waters around New Zealand, and to two limited localities, the Gulf of Panama and San Juanico Bay, Mexico, the latter representing a modification rather than an actual change in type.[9]

Outside the Pacific area there exist but a few scattered regions with mixed tides. The most extended of these outliers are the Arabian Sea and the oceanic side of the East Indies. These two regions are located at or near the ends of the only oscillating system of 24-hour period that can be assumed in the Indian Ocean[10] and are thus favored by a diurnal, as well as a semidiurnal, component. The same argument, however, does not hold true in the case of another exceptional occurrence of mixed tides, viz. at the east coast of central South America. Here, obviously, a node of semidiurnal oscillation favors the diurnal component, giving Porto Alegre a pure diurnal tide, whereas the tides north and south of the node are necessarily a transition to the normal semidiurnal tide of the Atlantic.

## Semidiurnal Tides

An oscillation of a 12-hour period is necessarily associated with oceans of smaller dimensions than those having mixed tides. In fact, all around the Atlantic depression the tides have a pronounced semidiurnal character. The only striking exception is the central part of the South American coast, to which reference has been made. The predominance of the semidiurnal type in the Atlantic area is so pronounced that the dependencies of the Atlantic, the North Sea and Hudson Bay, are under its influence, for the openings leading into these epicontinental seas are wide enough to permit the propagation of the Atlantic oscillation by progressive waves. The data obtainable from Arctic waters are yet too sporadic and unreliable to allow a positive conclusion as to whether these waters receive their tides exclusively from the Atlantic.

There exist, however, a few localities where the dimensions of a coastal basin tend to modify the type. This is, for instance, the case in Baltimore, because of the constriction of Chesapeake Bay at Cape Charles; likewise in Wilmington, S. C., which lies at the head of a very narrow estuary; and in Scoresby Sound, East Greenland. The type indices of these places are, however, not far from the marginal value of 0.25. A very marked semidiurnal tide characterizes the greater part of the Bay of Bengal. The fact that the Andaman Islands group has the same type of tide shows that this exceptional occurrence of a pure semidiurnal tide between two regions of mixed tides is

[9] Since the construction of the map is based on definite numerical values representing the type indices (see footnote 3) the tide types are separated by sharp boundaries and do not show possible gradual changes.

[10] Harris, *op. cit.*, Map No. 24.

not a mere coastal feature. The diurnal swing of the area between Arabia and Australia, which brings about the mixed tides of the Indian Ocean, does not affect the waters of the inner Bay of Bengal; indeed this area is somewhat protected by the protruding northern end of Sumatra and is therefore able to produce an independent oscillation of about semidiurnal period, as indicated by indices from 0.10 to 0.19.

The semidiurnal tides about New Zealand, around the southern tip of South America, and in the region of Kerguelen Island do not permit of any ready interpretation.

## Diurnal Tides

The diurnal tides must be called the most incomplete tides, since they reflect only the impulses given at intervals of about 24 hours. Their crippled character is also shown by the smallness of their ranges. The purest diurnal type never exceeds a mean spring range of 7 feet; in fact, ranges from 1 to 5 feet are the rule. The map exhibits a marked limitation of this type of tide to waters that may likewise be regarded as "crippled" when compared with regular ocean basins. The Gulf of Mexico, parts of the Caribbean Sea, and the extensive epicontinental waters known as the Australasian Mediterranean are, in fact, areas of peculiar shape and character. They are distinctly enclosed by chains of islands and therefore take no part in the general oscillation of adjoining oceanic areas. The diurnal tides of these regions appear to be the functions of depth rather than of any other dimensional features, since they are clearly confined to the shallower parts of the continental shelf.

There exist a number of outliers of this type of tide, whose sporadic distribution offers little indication as to their genesis. They are phenomena conditioned entirely by the nature of their locality. However, they may, in general, be explained by the following consideration. Wherever waves of semidiurnal period, either standing or progressive, interfere so as to neutralize each other at a certain place, the diurnal tide-producing forces, if they happen to synchronize, are likely to be felt very markedly and result in a tide of diurnal character. Such a local or regional diurnal tide is well illustrated by the tide curve of Victoria, B. C.

## Tideless Regions

Wherever a coherent area has an insignificant tidal range (less than 2 feet), the designation "tideless" has been applied in the world map. It is, of course, possible to assign also to these insignificant tides a distinct type, but the practical value of this distinction would be small. The European Mediterranean Sea and the Baltic Sea are

TYPES OF TIDE
Semidiurnal
Diurnal
Mixed
Tideless (under 2 feet)
Numbers indicate Mean Spring Range
The American Geographical Society of New York.
ARCTIC OCEAN
BERING SEA
NORTH PACIFIC OCEAN
SOUTH PACIFIC OCEAN
INDIAN OCEAN
SIBERIA
CANADA
UNITED STATES
ALASKA
AUSTRALIA
CHINA
INDIA
JAPAN IS
PHILIPPINE IS
NEW ZEALAND
MEXICO
GULF OF MEXICO
CARIBBEAN SEA
SOUTH AM
BAFFIN BAY
OKHOTSK SEA
JAPAN SEA
CORAL SEA
TASMAN SEA
BORNEO
NEW GUINEA
Caroline Is
Tuamotu Archipelago
WILKES LAND
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Lithographed by A. Hoen & Co. Baltimore

the best known tideless seas. Their location behind restricting inlets, viz. the Strait of Gibraltar and the Belts of Denmark furnishes the key to their tidal character. Being practically uninfluenced by the tides of the Atlantic, they have an oscillation of their own, which depends on depth and length. In the Baltic these dimensions are not sufficient to sustain any tidal oscillation at all, while the Mediterranean, though considerably deeper than the Baltic, is broken up into many divisions, none of which has dimensions large enough to produce appreciable tidal range. Range and tide in the Mediterranean Sea are, however, subject to considerable changes in spite of their relative weakness. Diurnal tides are a feature of the Dalmatian coast, while the Bay of Tunis has the exceptional range of 3 to 4 feet.

An entirely different cause underlies the virtual tidelessness of the oceanic centers. Unfortunately only the accidental occurrence of islands furnishes a means of determining the tidal ranges within the central parts of the larger oceans. It is but a logical surmise that such islands are located near the nodal lines of oscillating systems; any free oceanic location near the node of an oscillation is to be associated with small tidal range.

TABLE I—STATIONS WITH SEMIDIURNAL TIDES

*Type Index and Mean Spring Range (in feet)*

| STATION AND REGION | LATITUDE | LONGITUDE | INDEX | RANGE |
|---|---|---|---|---|
| Teplitz Bay, Franz Josef Land | 81 47 N | 57 59 E | 0.22 | 1.6 |
| Virgo Bay, Spitsbergen | 79 43 N | 10 52 E | 0.08 | 3.5 |
| Melville Island, Canadian Arctic | 74 47 N | 111 00 W | 0.17 | 3.8 |
| Kingua Fiord, Baffin Island | 66 36 N | 67 20 W | 0.04 | 20.4 |
| Godthaab, Davis Strait | 64 12 N | 51 44 W | 0.17 | 12.5 |
| Nottingham Island, Hudson Strait | 63 12 N | 77 28 W | 0.07 | 13.5 |
| Ashe Inlet, Hudson Strait | 62 33 N | 70 35 W | 0.05 | 30.0 |
| Kem, White Sea | 64 59 N | 34 50 E | 0.05 | 5.0 |
| Vardö, Norway | 70 22 N | 31 07 E | 0.11 | 9.0 |
| Discovery Harbor, Robeson Channel | 81 04 N | 64 44 W | 0.13 | |
| Jan Mayen Island, Greenland Sea | 71 00 N | 8 28 W | 0.17 | 3.6 |
| Port Burwell, Ungava Bay | 60 25 N | 64 46 W | 0.07 | 36.0 |
| Frederikshaab, Greenland | 61 59 N | 49 44 W | 0.22 | 9.0 |
| Bergen, Norway | 60 24 N | 5 18 E | 0.11 | 4.1 |
| Quebec, Canada | 46 49 N | 71 11 W | 0.19 | 14.6 |
| St. Johns, Newfoundland | 47 34 N | 52 41 W | 0.21 | 3.3 |
| Halifax, Nova Scotia | 44 39 N | 63 35 W | 0.20 | 5.2 |
| St. John, New Brunswick | 45 16 N | 66 03 W | 0.08 | 23.9 |
| Boston, Mass. | 42 21 N | 71 03 W | 0.16 | 11.0 |
| Sandy Hook, N. J. | 40 27 N | 74 00 W | 0.16 | 5.6 |
| Philadelphia, Pa. | 39 56 N | 75 09 W | 0.22 | 6.2 |
| Savannah, Ga. | 32 05 N | 81 02 W | 0.15 | 7.6 |
| Fernandina, Fla. | 30 41 N | 81 28 W | 0.18 | 6.9 |
| Cayenne, French Guiana | 4 56 N | 52 20 W | 0.16 | 6.0 |
| Georgetown, British Guiana | 6 49 N | 58 10 W | 0.17 | 7.8 |
| Ceará, Brazil | 3 41 S | 38 34 W | 0.07 | 8.2 |
| Pernambuco, Brazil | 8 04 S | 34 53 W | 0.09 | 7.0 |
| Puerto Madryn, Argentina | 42 46 S | 65 01 W | 0.08 | 13.2 |
| Comodoro Rivadavia, Argentina | 45 52 S | 67 29 W | 0.12 | 16.4 |
| Puerto San Julian, Argentina | 49 15 S | 67 41 W | 0.13 | 29.4 |
| Puerto Gallegos, Argentina | 51 37 S | 69 00 W | 0.10 | 45.6 |
| Cape Town, South Africa | 33 54 S | 18 25 E | 0.10 | 4.6 |
| Pointe Noire, French Equatorial Africa | 4 55 S | 11 50 E | 0.08 | 4.8 |
| Duala, Kamerun | 4 03 N | 9 40 E | 0.18 | 6.5 |
| Carabane, French West Africa | 12 33 N | 16 40 W | 0.07 | 3.9 |
| Dakar, French West Africa | 14 40 N | 17 25 W | 0.16 | 4.6 |
| Port Étienne, French West Africa | 20 55 N | 17 02 W | 0.07 | 5.5 |

TABLE I (continued)

| STATION AND REGION | LATITUDE | LONGITUDE | INDEX | RANGE |
|---|---|---|---|---|
| Casablanca, Morocco | 33 36 N | 7 37 W | 0.10 | 9.2 |
| Lisbon, Portugal | 38 41 N | 9 06 W | 0.07 | 12.0 |
| Fort Socoa, France | 43 24 N | 1 40 W | 0.07 | 12.2 |
| Brest, France | 48 23 N | 4 29 W | 0.05 | 19.5 |
| Cherbourg, France | 49 39 N | 1 37 W | 0.06 | 17.0 |
| Dover, England | 51 07 N | 1 19 E | 0.04 | 18.0 |
| Liverpool, England | 53 24 N | 3 00 W | 0.06 | 29.0 |
| Hull, England | 53 44 N | 0 20 W | 0.10 | 21.0 |
| Heligoland, Germany | 54 11 N | 7 53 E | 0.12 | 8.0 |
| Roter Sand, Weser, Germany | 53 51 N | 8 05 E | 0.10 | 13.0 |
| Suez, Red Sea | 29 56 N | 32 33 E | 0.09 | 7.0 |
| False Point, India | 20 25 N | 86 47 E | 0.18 | 6.8 |
| Dublat, Hooghly River, India | 21 38 N | 88 6 E | 0.10 | 11.2 |
| Akyab, Burma | 20 8 N | 92 54 E | 0.17 | 7.6 |
| Rangoon, Burma | 16 46 N | 96 10 E | 0.13 | 19.0 |
| Mergui, Burma | 12 26 N | 98 36 E | 0.09 | 18.0 |
| Port Blair, Andaman Island | 11 41 N | 92 45 E | 0.19 | 6.3 |
| Comoro Islands, Indian Ocean | 12 47 S | 45 17 E | 0.16 | 10.8 |
| Majunga, Madagascar | 15 50 S | 46 21 E | 0.11 | 10.9 |
| Tamatave, Madagascar | 18 08 S | 49 26 E | 0.16 | 7.3 |
| Durban, Natal | 29 53 S | 31 04 E | 0.17 | 5.6 |
| Betsy Cove, Kerguelen Island | 49 09 S | 70 12 E | 0.16 | 4.6 |
| Port Chalmers, New Zealand | 45 50 S | 170 42 E | 0.06 | 5.8 |
| Westport, New Zealand | 41 46 S | 171 37 E | 0.04 | 9.5 |
| Port Russell, New Zealand | 35 16 S | 174 18 E | 0.08 | 9.0 |
| Wellington, New Zealand | 41 17 S | 174 47 E | 0.11 | 3.6 |
| Port Hedland, Western Australia | 20 22 S | 118 36 E | 0.15 | 17.0 |
| Apia, Samoa | 13 46 S | 171 44 E | 0.11 | 3.1 |
| Gambier Island, Tuamotu Archipelago | 23 07 S | 134 57 W | 0.09 | 2.4 |
| Pingyang, Chosen | 38 38 N | 125 36 E | 0.25 | 16.0 |
| Jinsen, Chosen | 37 29 N | 126 37 E | 0.11 | 28.8 |
| Panama (Naos Island), Panama | 8 55 N | 79 32 W | 0.08 | 16.0 |
| Amoy, China | 24 23 N | 118 10 E | 0.20 | 15.5 |

TABLE II—STATIONS WITH DIURNAL TIDES

*Type Index and Mean Spring Range (in feet)*

| STATION AND REGION | LATITUDE | LONGITUDE | INDEX | RANGE |
|---|---|---|---|---|
| Pensacola, Fla. | 30 21 N | 87 16 W | 9.11 | 1.5 |
| Mobile Point (Fort Morgan), Ala. | 30 14 N | 88 01 W | 6.82 | 2.1 |
| Cat Island, Miss. | 30 14 N | 89 10 W | 5.26 | 1.7 |
| Galveston, Tex. | 29 19 N | 94 48 W | 2.62 | 1.5 |
| Tampico, Mexico | 22 16 N | 97 49 W | 5.9 | 1.3 |
| Campeche, Mexico | 19 50 N | 90 32 W | 1.55 | 2.1 |
| Vera Cruz, Mexico | 19 12 N | 96 08 W | 4.5 | 2.4 |
| Cristobal, Panama Canal | 9 21 N | 79 55 W | 1.9 | 1.1 |
| St. Thomas, Virgin Islands | 18 20 N | 64 56 W | 3.6 | 1.2 |
| Ponce, Porto Rico | 17 59 N | 66 40 W | 8.4 | 1.0 |
| Manila, Philippine Islands | 14 36 N | 120 57 E | 2.7 | 4.6 |
| Do-Son, French Indo-China | 20 42 N | 106 46 E | 2.0 | 7.6 |
| Quin Hone, French Indo-China | 13 45 N | 109 15 E | 2.5 | 4.8 |
| Koh Hlack, Siam | 11 48 N | 99 49 E | 13.3 | 5.6 |
| Haifong, French Indo-China | 20 52 N | 106 39 E | 17.5 | 4.3 |
| Tandjong Buton, Linga Island | 0 12 S | 104 36 E | 3.4 | 7.0 |
| Tandjong Kalean, Banka Strait | 2 00 S | 105 06 E | 4.0 | 8.8 |
| Pontianak, Borneo | 0 00 | 109 18 E | 3.4 | 3.8 |
| Soekadana, Borneo | 1 14 S | 109 58 E | 4.9 | 6.4 |
| Pulo Besar, Banka Strait | 2 54 S | 106 07 E | 3.5 | 7.1 |
| Ondiepwater Island, Billiton I. | 3 18 S | 107 11 E | 5.4 | 5.5 |
| Thousand Island (Duizend I.) | 5 36 S | 106 20 E | 5.5 | 2.5 |
| Edam Island, Java Sea | 6 00 S | 106 48 E | 3.0 | 2.2 |
| Tandjong Priok, Java Sea | 6 06 S | 106 54 E | 3.7 | 2.6 |
| Karimondjawa Island, Java Sea | 5 54 S | 110 24 E | 3.8 | 1.8 |
| Samarang, Java | 7 00 S | 110 24 E | 2.8 | 4.0 |
| Bawean Island, Java Sea | 5 52 S | 112 39 E | 8.1 | 5.2 |
| Sembilangan, Soerabaya Strait | 7 05 S | 112 42 E | 2.1 | 3.0 |
| Macassar, Celebes | 5 08 S | 119 25 E | 2.3 | 3.9 |
| Wakanai, Japan | 45 25 N | 141 40 E | 2.5 | 0.8 |
| Suttsu, Japan | 42 47 N | 140 16 E | 1.41 | 0.6 |

TABLE II (continued)

| STATION AND REGION | LATITUDE | LONGITUDE | INDEX | RANGE |
|---|---|---|---|---|
| Fukaura, Japan | 40 41 N | 139 59 E | 1.32 | 1.2 |
| Kamo, Japan | 38 48 N | 139 48 E | 1.48 | 1.2 |
| Maizuru, Japan | 35 27 N | 135 19 E | 1.27 | 0.8 |
| Toko, Taiwan | 22 28 N | 120 27 E | 1.4 | 4.0 |
| Finech Harbor, New Guinea | 6 35 S | 147 50 E | 1.9 | 5.0 |
| Fremantle, Western Australia | 32 03 S | 115 45 E | 3.36 | 2.1 |
| King George Sound, Western Australia | 35 08 S | 118 00 E | 2.48 | 2.6 |
| Port Dalrymple, Tasmania | 41 03 S | 146 47 E | .... | 9.0 |
| Langr Island, Gulf of Amur | 53 19 N | 141 26 E | 2.2 | 6.0 |
| Unalga Bay, Alaska | 54 00 N | 166 12 W | 2.5 | 2.9 |
| St. Michael, Alaska | 63 29 N | 162 02 W | 3.47 | 4.5 |
| Seymour Narrows, British Columbia | 50 08 N | 125 23 W | 1.3 | 8.0 |
| Victoria, British Columbia | 48 25 N | 123 24 W | 2.1 | 5.7 |
| Rio Grande do Sul, Brazil | 32 07 S | 52 04 W | 1.77 | 1.8 |
| Ratan, Gulf of Bothnia | 64 00 N | 20 55 E | 6.0 | 1.0 |
| Suakin, Red Sea | 19 07 N | 37 19 E | .... | 1.7 |

TABLE III—STATIONS WITH MIXED TIDES

*Type Index and Mean Spring Range (in feet)*

| STATION AND REGION | LATITUDE | LONGITUDE | INDEX | RANGE |
|---|---|---|---|---|
| Baltimore, Md. (Ft. McHenry) | 39 16 N | 76 35 W | 0.42 | 1.4 |
| Wilmington, N. C. | 34 14 N | 77 57 W | 0.33 | 3.0 |
| Nassau, Bahama Islands | 25 05 N | 77 21 W | 0.34 | 4.0 |
| Rio de Janeiro, Brazil | 22 54 S | 43 10 W | 0.40 | 4.2 |
| Montevideo, Uruguay | 34 53 S | 56 12 W | 0.3 | 3.5 |
| Buenos Aires, Argentina | 34 36 S | 58 22 W | 0.71 | 2.1 |
| Mar del Plata, Argentina | 38 05 S | 57 32 W | 0.7 | 4.0 |
| Port Louis, Falkland Islands | 51 29 S | 58 00 W | 0.4 | 4.3 |
| Hermite Island, Cape Horn | 55 51 S | 67 33 W | 0.43 | 4.8 |
| Valparaiso, Chile | 33 02 S | 71 38 W | 0.44 | 3.9 |
| Mazatlan, Mexico | 23 11 N | 106 27 W | 0.6 | 3.8 |
| Magdalena Bay, Mexico | 24 38 N | 112 09 W | 0.52 | 5.5 |
| Dan Diego, Cal. | 32 42 N | 117 14 W | 0.41 | 5.1 |
| Sausalito, Cal. | 37 50 N | 122 29 W | 1.0 | 6.0 |
| Astoria, Ore. | 46 11 N | 123 50 W | 0.56 | 7.8 |
| Clayoquot, Vancouver Island | 49 09 N | 125 55 W | 0.51 | 8.5 |
| Seattle, Wash. | 47 37 N | 122 20 W | 0.96 | 9.2 |
| Sitka, Alaska | 57 03 N | 135 20 W | 0.51 | 9.9 |
| Granite Cove, Alaska | 58 12 N | 136 24 W | 0.44 | 10.8 |
| Kokinhenic Island, Alaska | 60 18 N | 145 03 W | 0.53 | 5.0 |
| Kodiak Island, Alaska | 57 47 N | 152 24 W | 0.52 | 9.0 |
| Sanak-Peterson, Alaska | 54 24 N | 162 38 W | 0.8 | 5.7 |
| Point Barrow, Alaska | 71 18 N | 156 40 W | 0.47 | 0.6 |
| Flaxman Island, Alaska | 70 11 N | 145 50 W | 0.7 | 1.0 |
| Port Clarence, Alaska | 65 13 N | 166 24 W | 0.74 | 1.1 |
| Taraku Sima, Japan | 43 38 N | 146 20 E | 0.94 | 2.5 |
| Atsukeshi, Japan | 43 02 N | 144 31 E | 0.9 | 2.7 |
| Ohatake, Japan | 41 25 N | 141 10 E | 0.85 | 2.6 |
| Hirataka, Japan | 36 51 N | 140 48 E | 0.88 | 3.0 |
| Yokohama, Japan | 35 27 N | 139 38 E | 1.09 | 4.9 |
| Shimoda, Japan | 34 40 N | 138 57 E | 0.76 | 3.6 |
| Hamashima, Japan | 34 18 N | 136 45 E | 0.54 | 4.8 |
| Susaki, Japan | 33 23 N | 133 17 E | 0.52 | 5.0 |
| Yamakawa, Japan | 31 12 N | 130 38 E | 0.43 | 9.5 |
| Nagasaki, Japan | 32 44 N | 129 51 E | 0.35 | 8.4 |
| Tamsui, Taiwan | 25 11 N | 121 24 E | 0.3 | 5.8 |
| Naka, Okinawa I. | 26 23 N | 127 40 E | 0.43 | 4.0 |
| So-o, Taiwan | 24 35 N | 121 52 E | 0.54 | 5.8 |
| Miyakoshima, Ryukyu Archipelago | 24 48 N | 125 18 E | 0.45 | 4.9 |
| Taketomishima, Ryukyu Archipelago | 24 09 N | 124 05 E | 0.56 | 4.6 |
| Tsushima Sound, Chosen | 34 17 N | 129 21 E | 0.32 | 6.7 |
| Weihaiwei, China | 37 29 N | 122 13 E | 0.51 | 9.0 |
| Taku, China | 38 58 N | 117 43 E | 0.57 | 4.5 |
| Hongkong, China | 22 18 N | 114 10 E | 1.0 | 5.1 |
| Padang, Sumatra (Emma Haven) | 1 00 S | 100 18 E | 0.41 | 5.5 |
| Soerabaya, Java | 7 06 S | 112 42 E | 1.05 | 4.9 |
| Bajoewangi, Bali Strait | 8 11 S | 114 25 E | 0.5 | 7.8 |
| Tjilatjap, Java | 7 42 S | 109 00 E | 0.42 | 5.0 |

TABLE III (continued)

| STATION AND REGION | LATITUDE | LONGITUDE | INDEX | RANGE |
|---|---|---|---|---|
| Koepang, Timor Island | 10 12 S | 123 35 E | 0.58 | 4.9 |
| Swatow, China | 23 23 N | 116 39 E | 1.0 | 7.5 |
| Singapore, Malaya | 1 17 N | 103 51 E | 0.52 | 8.0 |
| Madras, India | 13 05 N | 80 17 E | 0.3 | 3.1 |
| Trincomali, Ceylon | 8 33 N | 81 13 E | 0.35 | 2.0 |
| Colombo, Ceylon | 6 56 N | 79 51 E | 0.32 | 2.0 |
| Cochin, India | 9 58 N | 76 15 E | 0.91 | 2.1 |
| Minikoy, Laccadive I. | 8 17 N | 73 18 E | 0.85 | 2.5 |
| Goa, India | 15 25 N | 73 48 E | 0.63 | 5.2 |
| Bombay, India | 18 57 N | 72 50 E | 0.36 | 12.0 |
| Karachi, India | 24 47 N | 66 58 E | 0.56 | 7.3 |
| Masqat, Arabia | 23 37 N | 58 35 E | 0.67 | 6.0 |
| Abu Shar, Persian Gulf | 28 59 N | 50 51 E | 1.14 | 2.6 |
| Aden, Arabia | 12 47 N | 44 59 E | 0.86 | 4.9 |
| Djibuti, French Somaliland | 11 35 N | 43 08 E | 0.8 | 5.5 |
| Port Louis, Mauritius Island | 20 08 S | 57 29 E | 0.5 | 1.6 |
| Reunion Island, Indian Ocean | 21 16 S | 55 35 E | 0.37 | 3.5 |
| Port Darwin, North Australia | 12 23 S | 130 37 E | 0.31 | 16.8 |
| Brisbane, Queensland | 27 20 S | 153 10 E | 0.33 | 6.4 |
| Sydney, New South Wales | 33 52 S | 151 12 E | 0.37 | 4.2 |
| Melbourne, Victoria | 37 52 S | 144 54 E | 0.39 | 2.8 |
| Port Adelaide, South Australia | 34 51 S | 138 30 E | 0.39 | 6.3 |
| Honolulu, Hawaii | 21 18 N | 157 52 W | 1.09 | 1.5 |
| Thorshavn, Faeroes I. | 62 02 N | 6 43 W | 0.73 | 4.6 |
| Beechy Island, Barrow Strait | 74 43 N | 92 00 W | 0.52 | 5.8 |
| Scoresby Sound, East Greenland | 71 30 N | 24 30 W | 0.35 | 3.5 |
| Tigil, Okhotsk Sea | 58 00 N | 158 12 E | .... | 7.3 |

# RIO DE JANEIRO AND SÃO PAULO*

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FIG. 1—Hinterlands of Rio de Janeiro and São Paulo-Santos and approximate outlines of the settlement areas of other coastal nuclei. Scale of the map approximately 1 : 60,000,000.

Very few of the world's "great cities" are located in the low latitudes. Outside of Calcutta and Bombay, Rio de Janeiro is the only other tropical city that has definitely surpassed the million mark, although São Paulo in 1928 was not far behind. That two such cities should have developed so close together in "underpopulated" Brazil is a fact that calls for interpretation. This paper presents a geographic description of Rio de Janeiro and São Paulo and some of the conditions of their formation and growth.

## The Regional Relationships

The fabric of settlement in Brazil is built on a pattern of relative simplicity. Closely woven near the urban centers or settlement foci, the strands fray out toward the frontier of western culture. All the chief foci of settlement are near the coast, and from each nucleus a fan of roads and railroads spreads out inland. Only loose interconnections have been established among these fans (Fig. 1). The result is a series of more or less separated units, integrated more closely by sea routes than by land routes, and each focusing on its own city. Rio de Janeiro and São Paulo are the cities of the two best-developed foci.

In North America and Europe we are accustomed to cities which have grown up at natural foci of the routes of travel. The pattern of settlement as guided by the configuration of the land converges naturally and easily on the great cities, so that their localization seems to have a certain inevitability. While this is a form of *a posteriori* reasoning that has no doubt been overworked in geographic interpretations of cities, there is a large number of cases where the importance of surface configuration in determining the foci of settlement cannot

*This paper presents some of the results of fieldwork in southeastern Brazil from June to December, 1930. The expenses of the fieldwork were supported in part by generous grants-in-aid from the National Research Council and from the University of Michigan.

be questioned. In southeastern Brazil, however, the lack of natural foci of routes converging from a large area is a notable fact. If the actual patterns of settlement now converge on a few coastal cities, this convergence is in large part artificial, in the sense that it has been accomplished in spite of the terrain and not with its aid. Too often have the descriptions, especially of Rio de Janeiro, lost sight of the

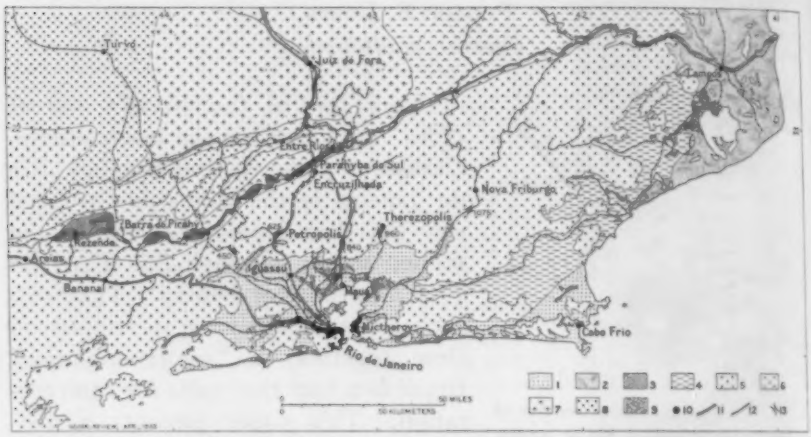


FIG. 2—The nearer hinterland of Rio de Janeiro. Numbers have reference: 1, Baixada Fluminense and other coastal lowlands; 2, Parahyba delta; 3, flood plains of middle Parahyba; 4, coastal terrace belt; 5, crystalline mountains; 6, Pomba-lower Parahyba depression (altitude about 500 meters) and middle Parahyba graben; 7, intermediate crystalline plateau (about 800 meters); 8, upper crystalline plateau (about 1000 meters); 9, marshes; 10, the old port of Estrella (near Mauá); 11, old São Paulo road; 12, old roads to Minas Geraes; 13, pass (elevation in meters). Compare the map cited in footnote 1. Scale of map approximately 1 : 3,600,000.

essential fact that this city is located in a place easily accessible to sea routes but difficult to reach by land.

## SURFACE CONFIGURATION[1]

The explanation of this lack of natural foci rests essentially with the intricate arrangement of the surface features. Excluding a coastal zone varying in width from nothing to somewhat over 75 kilometers, most of the hinterland of Rio de Janeiro and São Paulo lies at an elevation from 500 to over 1000 meters above sea level. For the most part the highland faces the sea with a steep escarpment some 800 meters high only slightly notched by the short coastal streams. The margin of the highlands is composed mostly of ranges of crystalline mountains of the block fault type, separated by structural valleys trending parallel to the coast. While passes through these mountains lie generally about 800 meters above sea level, the summits in many of the ranges reach 1800 meters and in three ranges surpass 2200.

[1] See pp. 231–234 and especially the map of the "Surface Configuration of a Part of Southeastern Brazil," Figure 3 in P. E. James: The Coffee Lands of Southeastern Brazil, *Geogr. Rev.*, Vol. 22, 1932, pp. 225–244.

Two deep river valleys have been cut through these marginal mountains, the Rio Doce and the Rio Parahyba. The Doce flows through a wide gorge in the mountains of Espirito Santo, providing a fine easy route of travel to the interior. The Parahyba, however, is not so valuable as a line of travel. Its orientation parallel to the coast makes it a barrier rather than a natural highway for those who would reach Minas Geraes. Its lower course from the head of the delta to Entre Rios (just north of Rio de Janeiro) is youthful, too narrow for land routes, and impossible for navigation. Its middle course, however, provides through a series of structural basins a good natural route for those who want to reach São Paulo, though difficult of access at each end. To reach the São Paulo basin from the elbow of the Parahyba at Guararema requires an ascent of 170 meters in 24 kilometers. Even then a range of mountains separates the São Paulo basin from the interior, and the Rio Tieté, which crosses this range, does so in a youthful gorge too narrow to provide a natural highway.

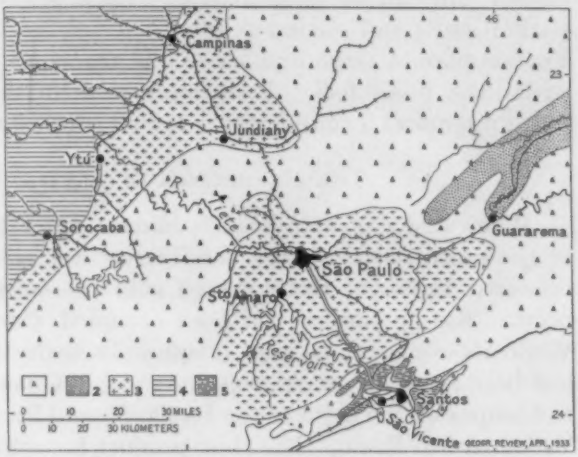


FIG. 3—The nearer hinterland of São Paulo-Santos. Numbers have reference: 1, crystalline mountains and plateau escarpment; 2, Parahyba graben (600 meters altitude); 3, São Paulo basin and front of crystalline oldland (800 meters); 4, Permo-Triassic inner lowland; 5, swamps. Scale of map approximately 1 : 2,400,000.

Inland from these ranges of mountains, furthermore, there are other obstacles to easy movement. In Minas Geraes the crystalline plateaus lie at three different elevations: a higher one, about 1000 meters, in the southwest; an intermediate one, about 800 meters, in central Minas Geraes; and a lower one, about 500 meters, in the southeast, in the valley of the Rio Pomba. The drop from the intermediate plateau to the lower one is abrupt and difficult to cross. Then, surmounting these several plateaus is the narrow but commanding range of the Serra do Espinhaço which quite effectively separates eastern Minas Geraes and the Rio Doce basin from the São Francisco basin to the west.

The surface features of São Paulo state are very different. In the first place the boundary between these two states is drawn along a northward projection of the crystalline mountains which makes

communication between them anything but easy and which in the south, north and east of São Paulo city, imposes a very real barrier. Most of São Paulo state is composed of stratified rocks, with east-facing cuestas and associated inner lowlands and water gaps.

Considering the area as a whole, then, there is no single natural outlet. Instead one is confronted with a bewildering array of small natural units and numerous small natural foci of minor importance. Furthermore, a large number of the towns do not correspond even with these lesser foci. An interpretation of the present settlement pattern requires a consideration of its historical development.

## The Beginnings of Settlement

When gold was discovered in Minas Geraes during the last decade of the seventeenth century the interior was still little known. The economic center of Brazil rested with the sugar plantations of the north. Rio de Janeiro had been occupied, chiefly as a naval base. While its connections were dominantly with the sea routes, roads had been extended inland from the shore of Guanabara Bay (Estrella) to Campos on the delta of the Parahyba and by way of the Parahyba Valley to São Paulo. The chief product brought over these roads to supply the small market at Rio de Janeiro was cattle.[2] The only place where a foothold on the plateau had been established was in São Paulo state, whence the restless Paulistas set out for various parts of the interior[3] (Fig. 4).

Gold made Rio de Janeiro, as surely as sugar made São Salvador and Recife and, as later, coffee made São Paulo. At the time of the establishment of the gold mining towns in Minas Geraes[4] there were five possible routes by which the mines could have been served and the product exported. The desire of the Portuguese crown to control completely the export of gold and later of diamonds resulted in the imposition of legal restrictions limiting all export to one route only—to Rio de Janeiro.

But why was Rio de Janeiro selected? Of the five possible routes, one would have followed the Rio São Francisco northward to Bahia. This would no doubt have been utilized on account of the early preëminence of São Salvador were it not for the great distances involved and the long overland trip necessary to avoid the falls near the mouth of the São Francisco. A more obvious route would have followed the Rio Doce, either to a port near its mouth, or to Victoria where a good harbor was available. The fact that this naturally most favorable route was actually never used was due to the presence

[2] C. M. Delgado de Carvalho: Geographia do Brasil, 4th edit., Rio de Janeiro, 1929, p. 340.

[3] F. J. Oliveira Vianna: O povo Brazileiro e sua evolução, *in* Recenseamento do Brasil . . . de 1920, Vol. 1, Introducção, Rio de Janeiro, 1922, pp. 279–400; reference on pp. 299 ff.

[4] O. A. Derby: Os primeiros descobrimientos de ouro em Minas Geraes, *Rev. Inst. Hist. e Geog. de São Paulo*, Vol. 5, 1899–1900, pp. 240–295.

until the early part of the nineteenth century of warlike Indian tribes in the mountains of Espirito Santo and especially along the lower course of the Doce.[5] In a sense the Rio Doce is the Mohawk Valley of Brazil, although its utilization as a great highway to the interior is even now only on the way to being realized.[6]

A third route by the Rio Parahyba to its delta would have required the sharp descent of the escarpment from the intermediate plateau level to the Pomba depression, but from there on the road would not have been difficult. Less favorable than the Doce, it was nevertheless better than the road to Rio de Janeiro, which required the climb from the Rio Parahyba to the crest of the mountains north of Guanabara Bay and the descent of the 800-meter escarpment that overlooks the Fluminense Lowland (Fig. 2). But the delta of the Parahyba provides no harbor. Campos was the center of a cattle industry[7] with overland connections—economically as far from the sea as if it had been in the interior.

The selection of the route to Rio de Janeiro instead of that to São Paulo resulted from causes both physical and historic. The Paulistas poured into Minas Geraes over two routes, both of which crossed some of the highest mountain ranges of this part of Brazil. But the possibility of capturing this territory for their own city was eliminated with their defeat in battle (1707–1709) before the hoards of newcomers entering Minas Geraes, chiefly from the depopulated sugar colonies of the north.[8] With the transfer of the seat of government to Rio de Janeiro in 1763 and the arrival of the Portuguese court in 1808, the preëminence of this town was effectively established over any possible rivals.[9]

## Early Roads in São Paulo

Meanwhile, although cut off from the Minas Geraes hinterland, São Paulo was not inactive. In addition to the road to Rio de Janeiro by way of the Parahyba Valley, other roads, tracks of the famous *bandeirantes*, led to the north and west. A number of towns had been established in the vicinity of São Paulo, each of them becoming

[5] Oscar Schmieder: The Brazilian Culture Hearth, *Univ. of California Publs. in Geogr.*, Vol. 3, No. 3, Berkeley, 1929, pp. 159–198; reference on pp. 186 and 187 and Map 3.

[6] The first attempts to utilize the Rio Doce as a commercial route to the interior are recorded in the following references: P. E. Ehrenreich: Land und Leute am Rio Doce (Brasilien), *Verhandl. der Gesell. für Erdkunde zu Berlin*, Vol. 13, 1886, pp. 94–107, especially pp. 99–100; and W. J. Steains: An Exploration of the Rio Dôce and its Northern Tributaries (Brazil), *Proc. Royal Geogr. Soc.*, Vol. 10 (N.S.), 1888, pp. 61–84, especially p. 64.

[7] Maximilian Alexander Philipp, Prinz zu Wied-Neuwied: Reise nach Brasilien in den Jahren 1815 bis 1817, Frankfort, 1820, pp. 107 ff.

[8] Roy Nash: The Conquest of Brazil, New York, 1926, pp. 130 ff.

[9] For descriptions of the roads focusing on Rio de Janeiro and their traffic during the first part of the nineteenth century see John Mawe, Travels in the Interior of Brazil, London, 1812; John Luccock: Notes on Rio de Janeiro and the Southern Parts of Brazil, London, 1820; J. B. von Spix and C. F. P. von Martius: Travels in Brazil in the Years 1817–1820, 2 vols., London, 1824; and Auguste de Saint-Hilaire: Voyage dans les provinces de Rio de Janeiro et de Minas Geraes, 2 vols., Paris, 1830.

the outfitting point for a trail leading to distant places. Jundiahy was a point of departure for Minas Geraes. Campinas was a focus of some potential importance, since one road ran northward along the edge of the crystalline upland into the savanas of Goyaz and another ran westward to follow the Tieté to Matto Grosso. Ytu was also an outfitting point for the Tieté route. Sorocaba, famous for its annual fair, was the point of departure for the south—for Paraná and distant Rio Grande do Sul.[10] A relatively easy pass across the mountains to the São Paulo basin led from Campinas by way of Jundiahy. The routes from Ytu and Sorocaba were not so obvious but, compared with other roads in Brazil, were not difficult. A certain degree of natural focus on the São Paulo basin from the interior of São Paulo state and beyond can, therefore, be maintained. But the 800-meter escarpment of the Serra do Mar lay between São Paulo and the parent colony of São Vicente. Lacking the wealth produced by gold, this whole territory remained a subordinate part of the hinterland of Rio de Janeiro, its pastoral and agricultural products aiding in the supply of that city.

## The Establishment of the Sao Paulo Hinterland

Then came coffee. It was first grown seriously in the Parahyba Valley along the road between Rio de Janeiro and São Paulo. For reasons discussed elsewhere,[11] the center of production shifted first to the vicinity of Campinas and later farther toward the interior of São Paulo state; northward beyond Ribeirão Preto; northwestward almost to Araçatuba; and southwestward into the northern part of the state of Paraná. Climatically the São Paulo basin was unsuited to coffee, and Campinas enjoyed a prosperity during the middle decades of the nineteenth century that was not shared by the parent city.

Various reasons are cited to account for the rise of São Paulo, which began in the last decade of the nineteenth century and assumed extraordinary proportions from 1912 to 1928. Campinas was subject to yellow fever, from which São Paulo was free. The 2° C. difference of summer temperature[12] between these two cities can scarcely account for a marked difference in their habitability. To be sure, São Paulo, occupying an easily drained site and very early having installed a system of drainage, had an advantage over poorly drained Campinas. But the essential cause for the rise of São Paulo seems to rest with the redevelopment of the natural focus of routes. While coffee was grown almost exclusively in the neighborhood of Campinas or in the territory to the north reached by way of that town, Campinas grew

[10] Affonso de Freitas Junior: Sorocaba dos tempos idos, *Rev. Inst. Hist. e Geogr. de São Paulo*, Vol. 27, 1929, pp. 99–118.

[11] James, *op. cit.*

[12] J. N. Belfort Mattos: O clima de São Paulo, São Paulo, 1925.

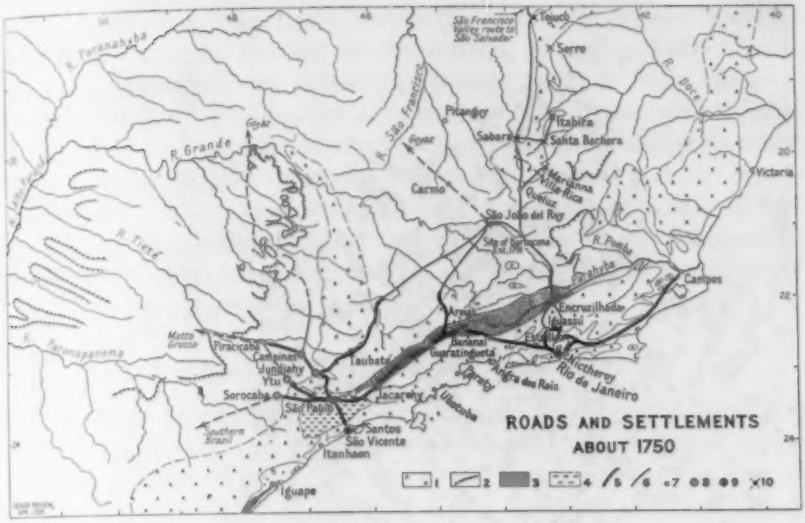


FIG. 4

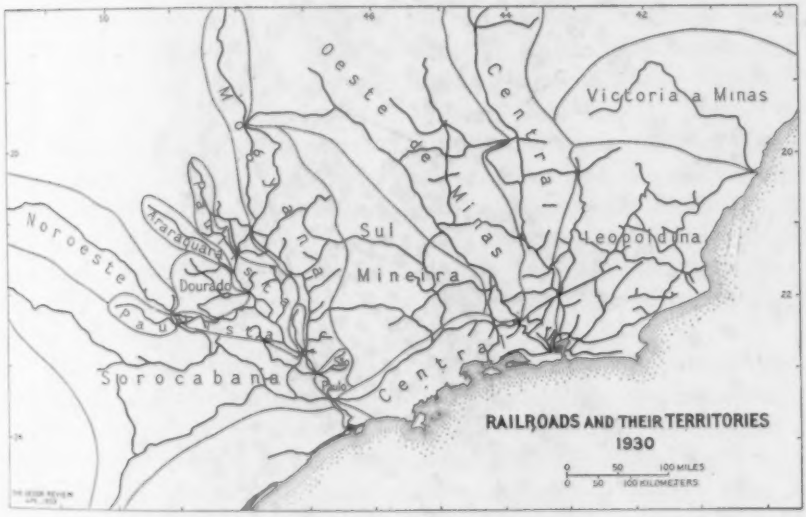


FIG. 5

FIG. 4—Chief settlements and road in the Rio de Janeiro-São Paulo region about 1750. Numbers have reference: 1, crystalline mountains; 2, escarpments; 3, middle Parahyba valley; 4, São Paulo basin; 5 and 6, roads (5, roads in existence in 1690); 7, chief towns; 8, outfitting towns; 9, parent colonies; 10, mining towns. Scale approximately 1 : 11,500,000.

FIG. 5—Railroads and the territories served by the chief systems, 1930. Compare with Figure 4.

in proportion to the prosperity of its hinterland. With the southwestward expansion of coffee, however, into the zone reached through Sorocaba—the zone of the Noroeste and Sorocabana railroads—the focal location of São Paulo again became an advantage. The construction of the Santos-São Paulo railroad in 1867 on a franchise that prohibited the development of competitive routes had already estab-

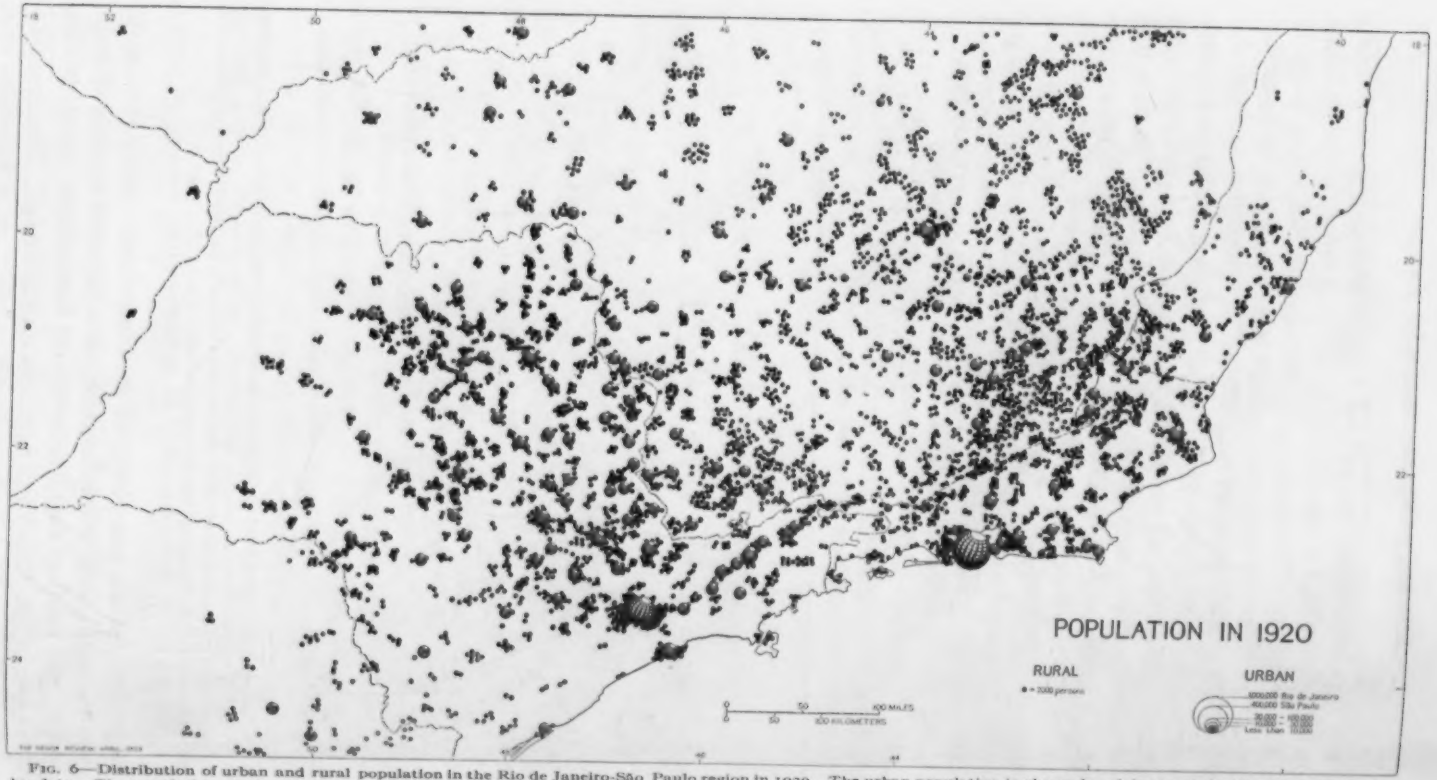


FIG. 6—Distribution of urban and rural population in the Rio de Janeiro-São Paulo region in 1920. The urban population is shown by globe symbols, the rural population by dots. The population of the urban area of the city of Rio de Janeiro was about 1,000,000, that of São Paulo about 400,000. Scale of map approximately 1 : 7,500,000. State boundaries are shown (see location map, The Coffee Lands of Southeastern Brazil, *op. cit.*, p. 933).

lished São Paulo as essentially a seaport. Otherwise Sorocaba might have sought another descent of the coastal escarpment directly to Santos, a connection now actually projected. Add to these things a number of special preferences for the port of Santos, such as the imposition of dock charges at other ports, which the powerful Paulista group was able to gain from the federal government, and the result was the final separation of the São Paulo hinterland from that of Rio de Janeiro. But without the wealth produced by coffee the natural obstacles in the way of development of the present foci of routes could never have been overcome.

## The Development of the Present Routes

The extent to which natural advantages for the location of routes, slender though they may be, have been disregarded in Brazil is too often not realized. The connections of Rio de Janeiro with its hinterland offer a striking illustration of this. Between the Fluminense Lowland and the Parahyba Valley most of the passes are between 600 and 900 meters above sea level; but one of them, leading to Barra do Pirahy, is much lower—only 450 meters. It has been maintained that this pass had partly accounted for the growth of Rio de Janeiro.[13] Yet, until the construction of the railroad from Rio de Janeiro to São Paulo by foreign engineers, this pass had never been of much importance. The colonial road to Minas Geraes took the more direct route over a higher pass to Encruzilhada, crossing the Parahyba at Parahyba do Sul. The road to São Paulo went over several mountain ridges to Bananal and descended to the Parahyba Valley at Areias. It is the Brazilian mode in road building to seek the shortest, most direct route with little regard for grades.

Railroads are tied somewhat more closely to the advantages offered by the terrain, although Brazilian railroads are notoriously ill-placed. During the early days of railroad construction the mountains north of Rio de Janeiro were crossed by three lines, only one of which, the line to São Paulo, took advantage of the low pass to Barra do Pirahy.[14] The main lines to Minas Geraes went by way of Petropolis and Nova Friburgo. Today the main line of the Central does go by way of Barra do Pirahy, descending the Parahyba to Entre Rios and thence turning to climb onto the plateaus of Minas Geraes. But Barra do Pirahy, a really important railroad junction, is a town

[13] Pierre Denis: Amérique du Sud (Géographie Universelle, Vol. 15) Paris, 1927, p. 170; and Delgado de Carvalho, *op. cit.*, p. 336; this error was avoided, however, by B. Kulicke: Buenos Aires und Rio de Janeiro; Versuch einer vergleichenden verkehrs- und siedlungsgeographischen Characteristik, Berlin, 1926, pp. 27 ff.

[14] Lionel Wiener: The Railways of Brazil, *Cassier's Magazine*, Vol. 38, 1910, pp. 83–91, and in scattered references in Vols. 38, 39, and 40. The parts dealing with southeastern Brazil are: Vol. 38, 1910, pp. 341–344; 456–471; 553–563; Vol. 39, 1910–1911, pp. 56–63; 164–173; 258–267; 337–354; 526–531; and Vol. 40, 1911, pp. 149–154. See also M. Vasconcellos: Vias Brasileiras de communicação, Rio de Janeiro, 1928.

State boundaries are shown (see location map, The Coffee Lands of Southeastern Brazil, *op. cit.*, p. 232). Scale of map approximately 1 : 7,500,000.

of small importance otherwise. Parahyba do Sul, at the old river crossing of the colonial trail, is still the chief town of this part of the valley. One gets used to railroad junctions with no habitations in sight and branch lines with important towns at their termini.

The present railroad system forms a fairly complete network especially in the coffee-producing areas. Both São Paulo and Rio de Janeiro have sent forth long tentacles to reach beyond the present frontiers of agriculture. Rio de Janeiro will seek to bring the São Francisco Valley within its territory. São Paulo has already established connections with southern Brazil and with the distant settlements of Matto Grosso. Both São Paulo and Rio de Janeiro compete for the capture of the cattle of Goyaz, with São Paulo at present somewhat ahead.

## The Hinterland of Rio de Janeiro

The hinterland thus conquered for Rio de Janeiro includes territory and resources of the greatest variety. In the first place, southern Minas Geraes, according to the census of 1920, is one of the most populous parts of Brazil (Fig. 6). One does not get the impression, to be sure, of a densely populated country in traveling through the area. Signs of decadence and abandonment strike the eye more frequently, perhaps, than signs of vigorous growth and productive settlement. However, there are thriving cities, such as Bello Horizonte and Juiz de Fora, which modify the impression of an empty land.

The permanent bases on which settlement of this territory will rest are not yet clearly defined. Brazil is a land of cheap labor, cheap land, and high transportation costs. Most products must seek a near-by market. In spite of a variety of physical conditions, agriculture is limited with little variation to the widespread combination of maize, rice, beans, manioc, and bananas. The earlier localizations of the money crops, sugar and coffee, are now rapidly fading out, either because of exhaustion of the soil, as in the case of the sugar of the delta of the Parahyba, or to competition with better-favored areas, as in the case of coffee. There are a few vague localizations, perhaps indicative of future patterns of distribution, such as the maize-hog combination of the high plateau of southwestern Minas Geraes in an area too cold for coffee. Rice shows a distinct concentration in the middle Parahyba Valley, although the economy of the area is still extensive. For more than a century the agriculture of Minas Geraes has been migratory,[15] so that the once extensive forests have been largely cleared. Most of the land has been used and abandoned perhaps more than once, and grassy pastures now predominate. The most important products are from the dairy cattle

[15] Saint-Hilaire, *op. cit.*, Vol. 1, pp. 191 ff.

of the south, especially the southwest, and the range cattle of the northwest. From these sources Rio de Janeiro derives an important part of its food supply.[16]

Minas Geraes, however, also includes among its resources a very great mineral wealth. Gold and diamonds are still produced, although not on the scale of the colonial period. But the minerals of the future are the deposits of manganese and iron. The former have been worked, especially during the war; but the iron reserves, possibly the richest in the world,[17] have scarcely been touched. The lack of coal will make the local use of these ores difficult in spite of the abundance of water power. The old forces that led to the development of the route to Rio de Janeiro, however, are no longer imperative. With the object of providing an easier outlet certain North American interests are now building a railroad up the Rio Doce,

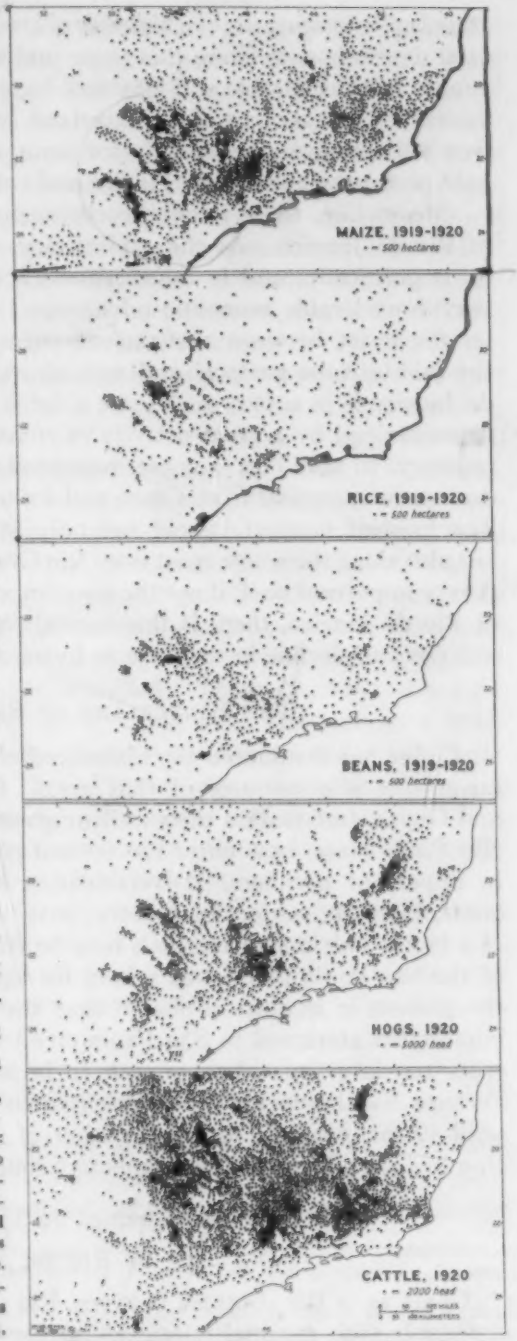


FIG. 7—Maps showing the acreage under maize, rice, and beans in 1919-1920 and the head of cattle and hogs, 1920. For coffee distribution see "The Coffee Lands of Southeastern Brazil," *op. cit.*, p. 227.

[16] C. M. Delgado de Carvalho: Chorographia do Districto Federal, Rio de Janeiro, 1926, pp. 88 ff.; and "Feeding Rio de Janeiro," *Brasilian American*, Rio de Janeiro, June 11, 18, and July 4, 1927, reprinted in *Bull. Pan Amer. Union*, Vol. 61, 1927, pp. 978–989.

[17] E. C. Harder and R. T. Chamberlin: The Geology of Central Minas Geraes, Brazil, *Journ. of Geol.*, Vol. 23, 1915, pp. 341–378 and 385–424; Euzebio Paulo de Oliveira: Mineral Resources of Brazil, Minist. da Agric., Indust., e Commerc., Rio de Janeiro, 1930.

thus finally making use of a highway of great natural advantage. Industrial developments along this route and at the new port, Santa Cruz, should be considerable and may well have the effect of robbing Rio de Janeiro of another part of its hinterland, now so loosely held. Perhaps iron will perform the miracle for some city on the Rio Doce that gold performed for Rio de Janeiro and coffee for São Paulo.

Meanwhile, there is another important aspect of the hinterland of Rio de Janeiro. As the capital city, the whole of Brazil focuses on it politically, and in South America the political focus carries a very considerable economic advantage. Furthermore, as mid-point on the coast between the ancient sugar regions of the north and the mid-latitude pastoral and agricultural regions of the south, Rio de Janeiro is in a very real sense a focus of sea routes. Connection is maintained by a great activity in coastwise shipping. The textile industry, to take one example, protected to be sure by a high tariff, draws raw materials from Ceará and from São Paulo through Santos. The finished product is sold not only in the immediate hinterland but also along the whole coast from Rio Grande do Sul to the Amazon.[18] A very important part, if not the most important part of the hinterland of Rio de Janeiro, then, is this coastal region,[19] and the capital city will rise and decline in response to forces affecting the whole nation.

### The Hinterland of São Paulo

Coffee has dominated the hinterland of São Paulo, but it is by no means the sole resource of that area. Cattle from Matto Grosso and Goyaz, fattened on the excellent grasses of northern and western São Paulo state, now enter the several packing plants of São Paulo in important numbers. Diversification of crops within the coffee lands, long the subject of oratory, may in the future become more of a fact. The lack of minerals may be offset by the real advantages of the São Paulo plateau as a land for agricultural settlement. For the present it is quite probable that the figure of about a million inhabitants attracted to São Paulo city by coffee speculation, represents too large an urban growth to be supported by its territory. Perhaps São Paulo must be contented to face a temporary setback until it can continue the occupation of its agricultural hinterland on a less speculative and economically sounder basis.

## The Development of the Urban Scene

### The Site of Rio de Janeiro

Great as is the contrast between Rio de Janeiro and São Paulo as regards their regional relationships, the contrast in their sites and

[18] Conference with Sr. Mark Sutton, Cia. Nova America de Tecidos, Rio de Janeiro.

[19] Denis, *op. cit.*, p. 200; see also J. Maia Forte: Esboço de geographia economica do Rio de Janeiro, Rio de Janeiro, 1919.

the way they have occupied these sites is even greater. Rio de Janeiro is unique among cities. If it does belong to a type of which there are other examples, none has reached the degree of elaboration of the Brazilian capital.[20]

The arrangement of the surface features in the vicinity of Rio de Janeiro is shown on Figure 8. South of the chief escarpment which marks the edge of the plateau there is an outlying mountain block. On the landward side, between the block and the main escarpment, is a lowland composed of knobby hills of low relief and broad, swampy valleys. This is known as the *Baixada Fluminense*, or the Fluminense Lowland. A downfaulted breach in the detached coastal range, scarcely two kilometers wide, forms the entrance to Guanabara Bay, some 412 square kilometers in area. The shores of the bay are shelving, difficult to approach from land or sea, excepting where the steep-sided spurs of the mountains extend finger-like into the water. The sugar-loaf type of hill, so familiar in the scenery of this place, is a characteristic form of the weathering of granites and gneisses in the rainy tropics and occurs, perhaps not so spectacularly, at other points along the coast from Victoria to Paranagua.[21] Between each promontory and its detached string of loaf-shaped islands the waves have built festoons of bay-head beaches including behind them marshy lagoons. Many of the islands, too, are land-tied. These shore forms are developed not only along the Atlantic but also, although to a lesser extent, along the mountainous parts of the bay shore. Characteristically in this climate only those beaches exposed to the beat of the heaviest waves are clear of vegetation. Elsewhere, as along the entire shore of the bay, a vigorous growth of mangrove fringes the water and chokes the lagoons and tidal inlets.

The selection of a site for the first town was governed by three considerations. The combination of a good anchorage, isolated hills for the location of a fort, and good water from the forest-covered slopes of the Serra de Carioca were the advantages offered by the "Carioca" shore.[22]

## The Early Settlement

In 1567 the Portuguese colony, already established on Guanabara Bay, built a fort on the Morro do Castello. This formed the original nucleus of the city. The essentials of the street pattern, the anatomy

[20] It is possible that there is a closer analogy between Rio de Janeiro and Lisbon than is commonly recognized. See Hermann Lautensach: Portugal, *Petermanns Mitt. Ergänzungsheft No. 213*, 1932, especially Chapter 11.

[21] Bernhard Brandt: Die tallosen Berge an der Bucht von Rio de Janeiro, *Mitt. Geogr. Gesell. in Hamburg*, Vol. 30, 1917, pp. 1–68; *idem:* Die Landschaft an der Bucht von Santos, *ibid.*, Vol. 32, 1919, pp. 93–116; E. Backheuser: A faixa litorania do Brasil Meridonal, hoje e ontem, Rio de Janeiro, 1918.

[22] C. M. Delgado de Carvalho: Historia da cidade do Rio de Janeiro, Rio de Janeiro, 1926, pp. 19 ff.

of the city, were fixed in the first few years. The port was developed along the shore between the Ponta do Calabouço and the Ilha das Cobras. While the political and military functions of the urban settlement were centered on the Morro do Castello, the commercial function centered especially on the Praça de Carmo (now the Praça 15 de Novembro). The short streets that ran inland from this *praça* (plaza) became the chief business streets, while the residences were strung out along the curving roads that developed concentrically around the shore north of the Morro do Castello.

The roads connecting the town with its immediate neighborhood became, in the course of time, the main elements of the larger city structure. Their courses were determined by details of the site that have since disappeared. In the first place, as has already been seen, the highways to the interior reached the shores of Guanabara Bay at Estrella, and the first railroad started at Mauá near by. Lighters connected Estrella and Mauá with the port of Rio de Janeiro. However, a road soon was built to connect Rio de Janeiro with the São Paulo and Minas Geraes highways. It started inland around the Mangue swamp, avoiding the mangrove-filled lakes and the soft shores of the Mangue. Its wandering course is preserved today in one of the main through streets leading to the suburbs of the modern city. In 1600 the level ground toward Tijuca, as well as in the other valleys that have since been invaded by the city, was occupied by sugar fazendas and sugar mills or *engenhos*. In the other direction from Morro do Castello a highway ran southward along the shore toward Botafogo and beyond, skirting the inner edge of the mangrove which screened the dry land from the deep water of the bay. It became the Rua do Cattete of the expanded city, for a long time the only through street to reach these southern suburbs.

These early roads formed the backbone to which later development was articulated. But development was slow.[23] Expansion took place first inland toward the Campo de Santa Anna, around the southern side of the Mangue, and along the road to Larangeiras.[24] In 1808, when the Portuguese Emperor came to Rio de Janeiro, some two centuries and a half after the site had been first occupied, practically nothing had been done to render the place more habitable. No serious effort to fill in the swamps or clear off the mangrove had been made, in spite of the epidemics of fever that the presence of

[23] J. Schack: Die Bevölkerung von Rio de Janeiro, *Geogr. Zeitschr.*, Vol. 2, 1896, pp. 48–49; Recenseamento do Brasil . . . de 1920, Vol. 2, Part Ia, População do Rio de Janeiro; Otto Quelle: Rio de Janeiro: Beitrag zur Geographie einer tropischen Grossstadt, *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1931, pp. 241–257, reference on pp. 248 ff.

[24] Numerous early maps of Rio de Janeiro are contained in the Biblioteca Nacional, Rio de Janeiro. From these was taken the material for the construction of Figure 8; see also the many references on early Rio de Janeiro contained in the *Revista do Instituto Historico e Geographico Brasileiro*, Rio de Janeiro, 1839 to date.

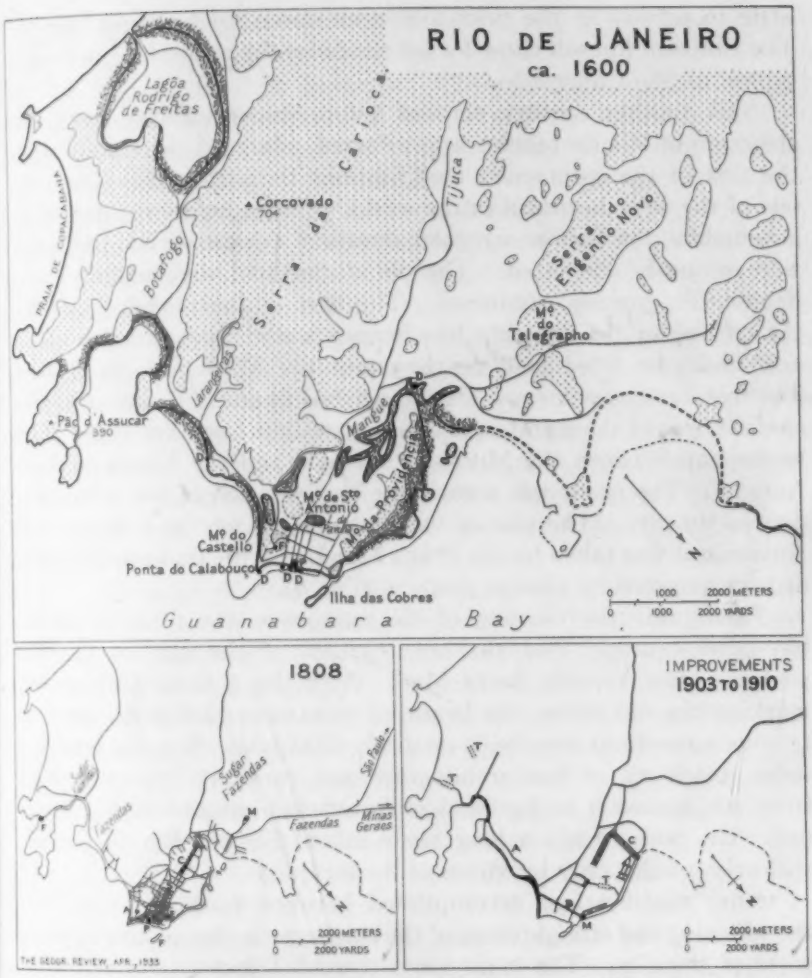


FIG. 8—The site of Rio de Janeiro and certain phases of its development. The map of the city about 1600 shows the shore line of the time by a heavy line; hills by stipple, with those that have been leveled distinguished by a broken line; mangrove swamps by the customary symbol; F, fort; D, docks; P, Praça de Carmo (now Praça 15 de Novembro).

The map of the city in 1808 shows the street development and the beginning of improvements with a canal for draining the Mangue swamp, C. Other references are: A, Castello; E, cemetery; F, forts; M, the sugar estate at São Christovao shortly afterwards converted for use as the Emperor's Palace; P, Praça de Carmo; S, Campo de Santa Anna.

Important modifications made between 1903 and 1910 include the cutting of Avenida Rio Branco, B, from the Praça Mauá, M, and the improvement of the Rua do Cattete, A, and other of the arterial roads (T indicates tunnels), and the Mangue Canal, C.

these breeding places for mosquitoes made common. The first important improvement of this sort appears on the map for 1808 (Fig. 8), on which a canal is shown beginning the work of draining the Mangue swamp. The shallow lakes near the center of the town, such as the Lagoa da Pavuna, were also filled in about this time. Yet there was

little to admire in the primitive town described by Saint-Hilaire.[25] The Emperor himself chose for his residence the estate of a rural sugar grower at São Christovão.

Still another century elapsed before important changes in the structure of Rio de Janeiro were effected. In 1903 there was started the first of the spectacular modifications that make this city today one of the most beautiful in the world.[26] Even before the day of the automobile, the narrow, irregular streets of downtown Rio de Janeiro were seriously congested. The old docks, too, were inadequate to handle the growing commerce. The first of the modifications was the cutting of the Avenida Rio Branco and the construction of the new docks on filled land northwest of the Morro da Providencia. The tree-lined avenue, now often described as one of the most impressive avenues of the world, was cut in a straight line from Praça Mauá to the gap between the Morro do Castello and the Morro de Santo Antonio. The result was a complete reorientation of the commercial core of the city. The rôle of the Praça de Carmo (now Praça 15 de Novembro) was taken by the Praça Mauá, and the business and retail district assumed its present position (Fig. 9).

Then came the clearing of the mangrove, the filling in of the bay-head swamps, and the construction of the famous bay-side parkway, the Avenida Beira Mar. With the Rua do Cattete still marking the old shore, the beautiful structures of Rio de Janeiro's famous water front were built on newly filled land. Yet this imposing scene, made up of fine architecture and carefully improved shore front set against a background of forest-clad mountains, is literally only skin deep. Only a long block inland lies old Rio de Janeiro, still ugly, quaint only by virtue of its antiquity.

Other modifications accomplished between 1903 and 1910 were the widening and straightening of the chief arteries connecting outlying parts of the city. The main route toward Tijuca was straightened where a long-filled swamp had once enforced a detour. The Mangue Canal was lined by highways and twin rows of stately royal palms. A straight road was cut through the Botafogo district. Then, to reach the new residence districts along the Atlantic on Praia Copacabana, tunnels were cut through the intervening range of hills. A very new Rio de Janeiro was in the making.

## Rio de Janeiro Today

The present-day city, with its functional areas, is shown on Figure 9. This map reveals an unusual pattern of distribution, strangely

[25] Saint-Hilaire, *op. cit.*, Vol. 1, pp. 51 ff.; see also Ernst Ebel: Rio de Janeiro und seine Umgebungen im Jahr 1824 *in* Briefen eines Rigaers, St. Petersburg, 1828.

[26] F. A. Georlette: La métamorphose de la capitale du Brésil, *Compte Rendu Trav. IXe Congr. Internatl. de Géogr.*, Genève, 1911, Vol. 3, pp. 96–105.

composed of relict forms and modifications imposed by an ambitious program of city planning not yet completed. Consider, for example, the distribution of factories. There is some concentration in the Mangue district and along the water front northeast of Morro da Providencia. There are a number of manufacturing suburbs along the railroad lines to the northeast of the main part of the city. But important factories are scattered literally from one end of the urban area to the other. There are factories in the midst of the superior residence districts both of Botafogo and of Tijuca. The forces producing this distribution are various. In the case of the textile companies beyond Botafogo near the Lagoa Rodrigo de Freitas the ownership of land, which it was desired to develop by the sale of small lots to the factory workers, furnished a motive for the location of the factory. Other factories came to the vicinity attracted by the surplus of workers who had gathered about the first establishment.[27] In a remarkable number of instances proximity to labor and even the ownership of land were forces that outweighed access to railroads and docks.

A large number of Rio de Janeiro's industrial establishments, however, are of the workshop type. The "local retail and workshop" district is a combination not found in North American cities. Included among a not unusual array of grocery stores, meat markets, dry goods stores, restaurants, and bars there are numerous buildings only parts of which are devoted to industry: to the construction of furniture, to small clothing establishments, and to many other small-scale operations requiring the services of only a few workmen. In many cases the products are sold at retail in the front of the buildings. The study of this type of organization would make an interesting project for an economist.

The residence districts, also, show a peculiar pattern of distribution. The most modern superior residence districts are along the ocean front in Copacabana and the other ocean beaches. The most important "foreign" districts of Rio de Janeiro are found here. Other superior residence areas are found in Botafogo, where many of the properties date back to the sugar *fazenda* period. There are similar patches in Tijuca. The old superior residence district near the Emperor's Palace, now a museum, has become decadent as a result of the invasion of factories near by. This is one of the few examples in Rio de Janeiro of a decadent inner residence zone, so common a feature of rapidly growing European and North American cities. In only a few places are superior residence districts located on the hills.

Many of the poorest residence districts, on the other hand, are located on the hills. To be sure, there are poor districts in the valleys,

[27] Quelle, *op. cit.*, pp. 254–255: half of the industries in Rio de Janeiro were established during and after the World War, between 1915 and 1919.

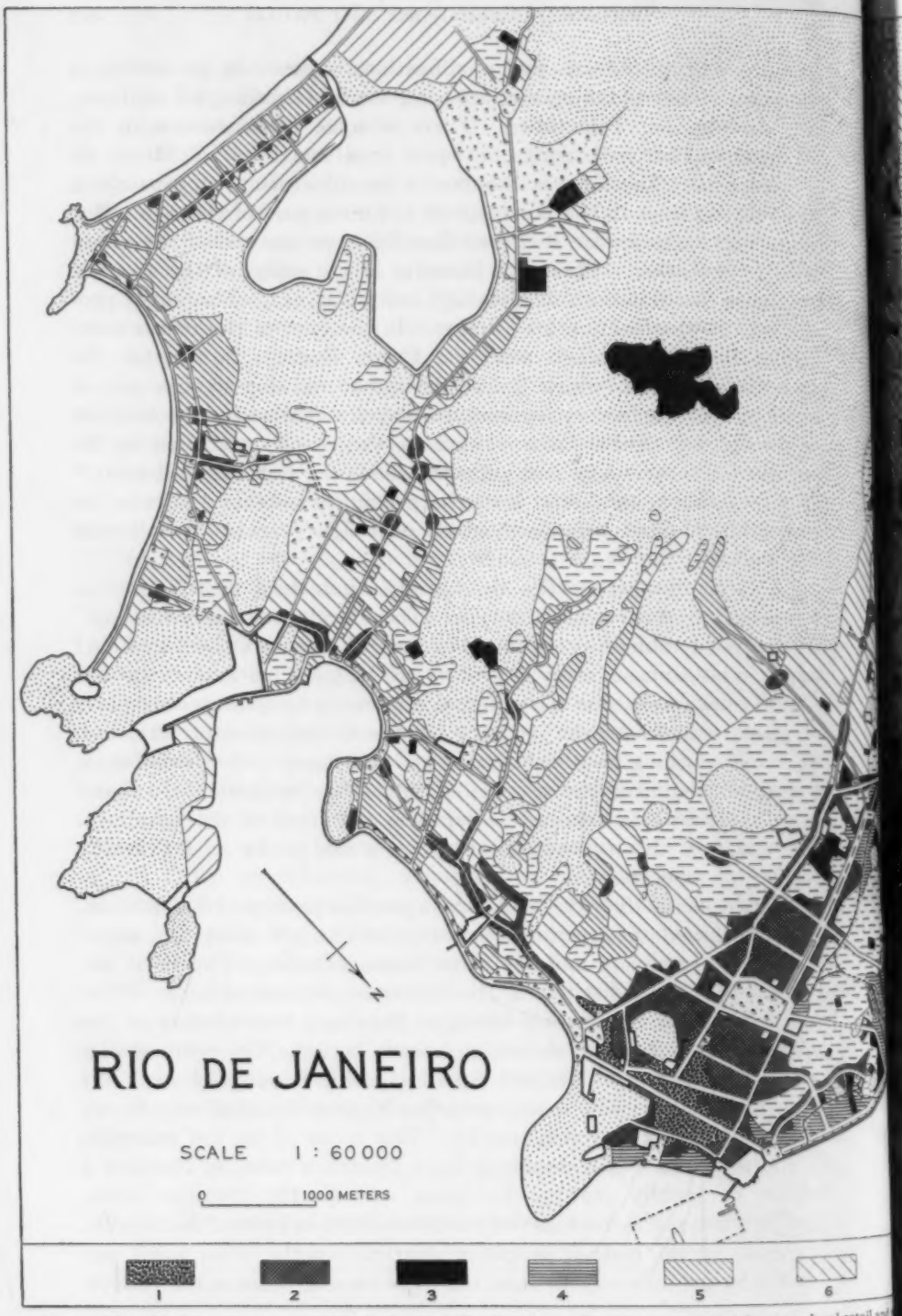


FIG. 9—Map of the functional areas of Rio de Janeiro. Numbers have reference: 1, commercial core; 2, local retail and
shop district; 3, industries; 4, land devoted to transportation (railroads, railroad yards, warehouses for storage of goods in b

l retail and
f goods in
, etc.); 5, superior residence district; 6, ordinary residence district; 7, ordinary suburban residence district; 8, poor residence
t; 9, poor suburban residence district; 10, public buildings; 11, parks, playgrounds, cemeteries; 12, vacant or agricultural land.

generally in places that formerly were too swampy for the successful cultivation of sugar. One of the worst of these is the Mangue district. But it is on the sides and tops of the hills that one finds Rio de Janeiro's most striking slums, or *favellas*. The Morro da Providencia may

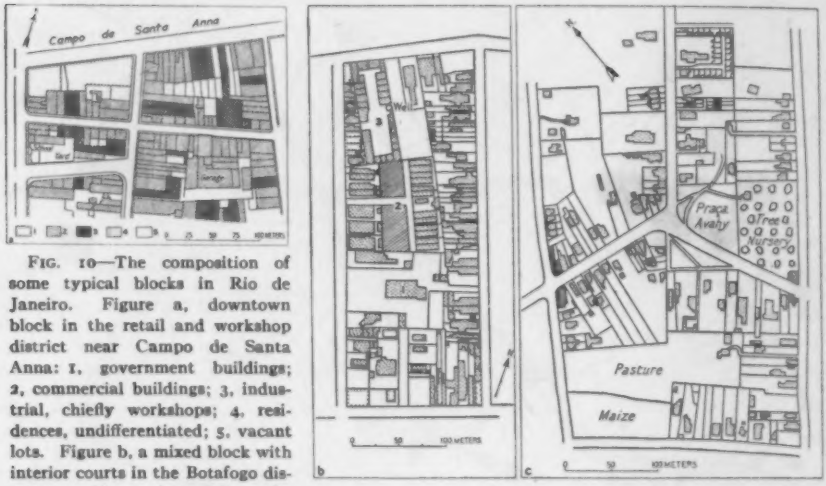


FIG. 10—The composition of some typical blocks in Rio de Janeiro. Figure a, downtown block in the retail and workshop district near Campo de Santa Anna: 1, government buildings; 2, commercial buildings; 3, industrial, chiefly workshops; 4, residences, undifferentiated; 5, vacant lots. Figure b, a mixed block with interior courts in the Botafogo district: 1, old superior residence, for a time the British Embassy; 2, garden plots; 3, cortiço or interior court. Figure c, a suburban section, Praça Avahy.

serve as an example. Here, almost within a stone's throw of the commercial core, clinging to the steep slopes is a community dwelling in the most primitive mud huts without light, water, or sewerage, even without organized streets—a squatter settlement without order or organization. There are jungles, of course, in other cities; the peculiarity of these *favellas* of Rio de Janeiro is their position, not in a swampy valley or between the docks of an unhealthy water front, but perched in a dominating and commanding outlook on the city's hills.

Another form of the poor residence district is the interior court, placed in the midst of ordinary or even superior residence areas. One narrow entrance from the street gives access to this beehive of humanity. A row of tightly packed small huts face a cobble-paved court. In this confined space is crowded a social organization of a remarkable and rather sordid kind[28]—a mine of material for a sociologist. From these places issue the multitudes of porters and unskilled workers whose heartbreaking competition for the smallest job brings wages to very low levels, but who prefer even such a life to the loneliness of the rural districts. Around the well of the court is the laundry; and, while the women appropriate the cobble pavement to spread out their washing to dry, the hordes of children are chased to the streets.

[28] See the graphic description in the novel by the Brazilian author Aluizio de Azevedo: O cortiço (The Beehive), Rio de Janeiro, [1890?]; translated into English as "A Brazilian Tenement," New York, 1926.

It seems surprising that the presence of such a courtyard or of a factory should not lower the value of the neighboring residences. Perhaps it does to some extent, although the rent from these "tenements" must more than make up the loss. Another fact which explains the close juxtaposition of such contrasted utilities is that in Brazil every house is surrounded by a wall: it is a stronghold, a castle, a self-contained unit, to a large extent isolated from its neighbors. A peculiarly mixed and scattered type of distribution is thus made possible.

An interesting negative feature of the structure of Rio de Janeiro is the complete absence of anything resembling a "Coney Island" along the Praia Copacabana. In a North American city this fine beach would be sought regularly by great numbers of people from all over the city. The relative lack of mobility of Rio de Janeiro's population explains the absence of anything of the sort here. Many families living in the northwestern suburbs of the city have literally never been to the ocean front, probably by reason of the combination of tradition and poverty.

Rio de Janeiro extends inland for many kilometers through a gradually thinning suburban zone, a distinctly recent development, permitted by the very cheap fares on the railroads. Its suburbs have pushed beyond the coastal range and invaded the Fluminense Lowland.

## The Future Rio de Janeiro

Rio de Janeiro has not stopped the improvement of its inherited structure. A French urbanist, M. Alfred Agache, has worked out a plan for a new Rio de Janeiro which calls for a reorganization of the urban structure on a big scale.[29] The originality and daring of his plan makes one hope that means may be found to carry it through. Already the first steps have been taken. The famous Morro do Castello has been razed, and the Ponta do Calabouço has been extended and reshaped with the material thus made available. Agache plans the establishment on this new land of a future commercial core planned as a unit which, in completion, would make Rio de Janeiro one of the wonders of the world. The Morro de Santo Antonio is in process of being removed. The docks and railroad terminals are to be constructed on an ambitious scale northeast of their present location. These things have been started. Their completion, the cutting of new avenues and the successful shifting of the various functions to the new areas assigned to them, remains for the future. But the success of the whole scheme rests, it would seem, on the development in the hinterland of Rio de Janeiro of a demand for the functions of a great city on the scale provided for in the plan.

[29] A. Agache: Cidade do Rio de Janeiro; extensão, remodelação, embellezamento, Paris, 1930.

## The Site of São Paulo

The contrast between São Paulo and Rio de Janeiro is extraordinary. There is, of course, a great difference in the physical setting of these cities: but the contrast is not only in the quality of their sites. Although the site of São Paulo was occupied by a Jesuit mission in 1554 and the city thus antedates the founding of Rio de Janeiro, modern São Paulo is much more recent and more a product of the world-wide industrial culture associated with the twentieth century and, perhaps wrongly, with North America.[30] The cities developing under this culture type are more or less cut to a pattern—a pattern that is making the great cities of the world look more and more alike, however divergent may have been their beginnings. São Paulo for three centuries and a half was a typical Brazilian town without much to distinguish it from many others. Then came coffee, European immigrants, immigrants from other parts of Brazil seeking the new El Dorado, and finally a huge industrial structure raised behind the bulwarks of a high tariff in typical North American fashion.

The São Paulo basin is a base-leveled plain, now uplifted 800 meters above the sea and dissected by the Rio Tieté and its tributaries to a relief of some 60 or 70 meters. Flattish ridge tops throughout the basin mark the remnants of the former plain. The streams, which rise somewhat inland from the crest of the coastal escarpment, flow through broad marsh-lined valleys inundated after heavy rains. Along the sides of most of these valleys there are well developed terraces varying in elevation above the flood plains from only a meter or so to the highest one at about 20 meters.

When the Jesuits ascended the plateau from São Vicente two considerations governed their selection of a site for their mission. One was accessibility to the highway, and the other was defense.[31] Since the ridge tops are not sufficiently continuous to be utilized for the roads, the main lines of travel used the valleys or the lower terraces. Near the place where the road from São Vicente reached the Tieté Valley a triangular bit of the higher terrace, almost isolated by the junction of the Tamanduatehy and the Anhangabahu, furnished the necessary eminence for defense and for the establishment of a church.

Figure 11 shows the surface features of the modern São Paulo. The swampy valley bottoms are for the most part easily distinguished from the lowest of the terraces, although in the Braz district, which is only a meter or so above the flood plain of the Tamanduatehy, the grading of the city has all but eliminated the rise. The slopes

[30] Bruno Dietrich: Nordamerikanische Stadtlandschaften, *in* Stadtlandschaften der Erde, herausgegeben von Siegfried Passarge, Hamburg, 1930, pp. 144–154.

[31] Theodoro Sampaio: A fundação da cidade de S. Paulo em 25 de Janeiro de 1554. *Rev. Inst. Hist. e Geogr. de São Paulo*, Vol. 10, 1905, pp. 524–528; reference on p. 527.

between the various terraces have in many cases been smoothed off, so that, in mapping, the several levels were not differentiated. These terraces are generally flat-topped and, where the tributaries of the Tieté have cut headward through them, steep-sided. From the highest terrace the land rises in long, graceful curves to the ridge in the background. On the southern side of the main ridge the land drops off again to the valley of the Pinheiros, another south-bank tributary of the Tieté which joins the main stream at some distance to the west of the city.

## Early São Paulo

The first century of São Paulo saw the development of a street pattern in close adjustment to the configuration of its site. The famous "triangle"—modern São Paulo's business section—is to that city what the "loop" is to Chicago. The filling in of the triangle and the spread across the Anhangabahu to the Campos Elyzeos was accomplished during the first century, after which the town did little more than maintain itself.[32] The map of São Paulo in 1810 is the map of a town that, in a static condition, had watched the passage of some two centuries.

Even the nineteenth century did not witness the metamorphosis of São Paulo. As we have already seen, Campinas was experiencing a larger growth than São Paulo until the spread of coffee to the zone of the Sorocabana Railroad after 1890. The map for 1891, then, shows a typically Brazilian town just before the beginning of its transformation to the modern industrial metropolis. The main lines of its structure had been established, such as the avenues of approach from Santos, from Rio de Janeiro, and from Sorocaba and Campinas, which united west of the town, and from the agricultural section north of the Tieté, which focused on the little town of Sant' Anna.

The increase of population in São Paulo during the first quarter of the present century shows a typical North American curve. A population of some 239,000 in 1900 had about doubled by 1920, reaching 579,000. In 1928 the city is estimated to have passed a million,[33] though considerable decline is consequent on the present industrial depression. It is this enormous growth up to 1928 that has produced modern São Paulo.[34]

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[32] Theodoro Sampaio: S. Paulo no seculo XIX, *Rev. Inst. Hist. e Geogr. de São Paulo*, Vol. 6, 1900–1901, pp. 159–205; reference on p. 168.

[33] The population of the city of São Paulo on December 31, 1928, was estimated at 1,009,249 and on December 31, 1929, at 879,800 (J. Garnett Lomax: Economic Conditions in Brazil, December, 1931, *Rept. British Dept. of Overseas Trade No. 506*, 1932, p. 64).

[34] L. E. Elliott: Old and New São Paulo: The Rise of a Business City, *Pan-American Mag.*, Vol. 22, 1916, pp. 295–308; M. A. Phoebus: São Paulo, the Industrial Metropolis of South America, *Commerce Repts.*, April 12, 1926, pp. 76–80; G. Hoch: Die geographische Lage von São Paulo, São Paulo, 1928.

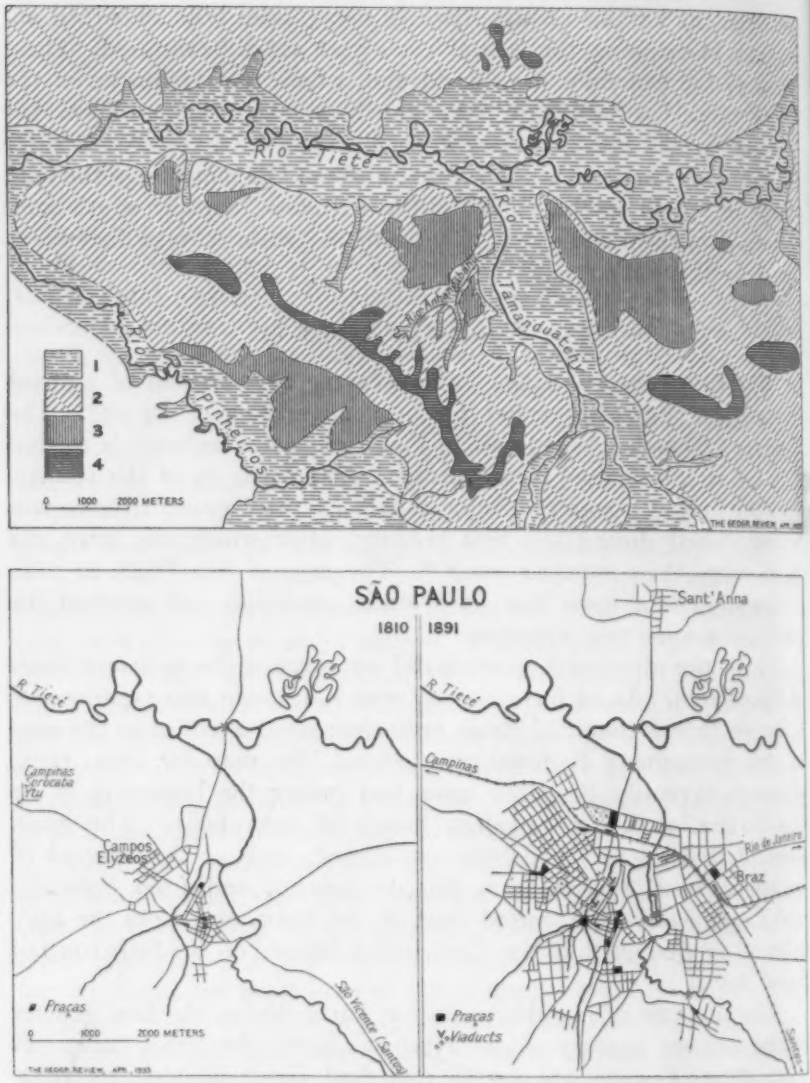


FIG. 11—The site and development of São Paulo. References to surface configuration: 1, valley bottoms, swampy and difficult to drain (altitude about 730 meters); 2, intermediate slopes, rounded, convex, graded slopes of moderate inclination; 3, lower terraces of Tieté and tributary valleys (about 745 meters); 4, flattish remnants of original floor of São Paulo basin (about 800 meters). Scale of the upper map approximately 1 : 180,000; scale of the lower maps 1 : 124,000.

## MODERN SÃO PAULO

The extent to which the present city is constructed on the mode of the industrial-commercial metropolis is revealed by the map of the functional areas in 1930. Unlike Rio de Janeiro its various districts are quite homogeneous. In a general way the city pattern is arranged concentrically around a compact commercial core, but the

intimate manner in which the various forms of land use are adjusted to the accidented terrain is an outstanding feature.

Around the outside of the commercial core is a zone of local retail stores and workshops, similar to the one in Rio de Janeiro. Included in this area in São Paulo, however, there are a number of decadent superior residence sections of the nineteenth century town, especially in the old Campos Elyzeos district. The zone of local retail stores extends, star-shaped, along the various converging avenues of approach to the core. Beyond this, again, lie the factory districts. These, however, do not form an unbroken circle. The industrial establishments—most of them of recent origin—are located on the flat, swampy land of the valley bottoms or the somewhat drier land of the lowest terrace. With few exceptions, moreover, they are easily accessible to the railroads. These enter the city from Campinas and Sorocaba up the Tieté and from Rio de Janeiro down the Tieté, in both cases following the lower terrace or the outer edge of the flood plain. The railroad from Santos descends the Tamanduatehy but departs from it to pass through the Braz district on the lower terrace before entering the Tieté Valley.

The distribution of the residence districts is typical of this kind of city. Poor residences fill in around the factories near the center of the town or form isolated districts near the outlying plants. Congested slums analogous to the *favellas* of Rio de Janeiro occupy some of the narrow bottoms of the valleys heading back into the main ridge. Until recently the Anhangabahu contained such a slum, which the traffic of the city passed over on viaducts. This has been cleaned out to form a beautiful parkway in the very heart of the city.

The superior residence districts occupy the higher ground. Excepting for a few remnants of the old superior district closer downtown, the new residences occupy the top and shoulders of the high-level ridge overlooking the city from an elevation of more than 50 meters. Then, beyond the ridge, the city has poured into the valley of the Pinheiros. New residential subdivisions, laid out on the most approved modern patterns, have been occupied as superior districts at much lower elevations near the outskirts of the present city.

São Paulo is surrounded by one of those remarkable penumbras of unoccupied real estate subdivision that mark the scramble in modern rapidly growing cities for a share of the unearned increment. For great distances from the center of town these subdivisions have been laid out: to the west along the high-level ridge and its slopes; to the north along the northern bluffs bounding the Tieté Valley; to the east on other bits of the high ridge; and far to the south toward Santo Amaro. On paper, even the reclaimed Tieté Valley has been subdivided. Residence space enough to provide for a city of many millions is available for occupation or speculation.

FIG. 12—Map of the functional areas of São Paulo. The numbers have reference: 1, commercial core; 2, local retail and workshop district; 3, industries; 4, land devoted to transportation (railroads, railroad yards, warehouses for storage of goods in transit, docks, etc.); 5, wholesale district; 6, superior residence district; 7, superior suburban district (less 50 per cent of each block

built up); 8, ordinary residence district; 9, ordinary suburban residence district; 10, poor residence district; 11, poor suburban residence district; 12, public buildings; 13, parks, playgrounds, cemeteries; 14, vacant or agricultural land.

Nor is São Paulo without its planning commission. Amply aware of the developments in other countries of the science and art of city planning, the Paulistas have worked out for their city a plan, calling for the reclamation of the Tieté Valley, the paving, widening, and straightening of the main arteries of travel, the construction of subways, and other improvements.[35] Nothing in the plan, however, calls for such a wholesale reorientation of the functional pattern as was accomplished of necessity in Rio de Janeiro with the cutting of the Avenida Rio Branco or as is projected with the shift of the commercial core to the new Ponta do Calabouço.

## Conclusion

São Paulo and Rio de Janeiro, then, express quite different modes of city building. There are few cities in the world that to a greater degree than São Paulo embody the principles of urbanism in vogue at the present time. In contrast Rio de Janeiro is unique among cities—the most elaborately evolved example of the Brazilian, possibly the Portuguese urban mode.

Neither of these cities, however, can be said to exist by virtue of the natural focus of communications from large and productive hinterlands. Both cities have conquered territory and established regional foci in spite of obstacles. Great as is this accomplishment, it must be remembered that the physical obstacles still exist to render the maintenance of the present hinterlands less certain. The loose attachment to the land characteristic of the present settlement in the rural areas adds to the uncertainty of the future. Neither city is so firmly established that it can neglect its grasp of a hinterland. Projects to promote a closer attachment to the land and a more effective utilization of the interior should not be overshadowed by schemes of urbanization however grandiose.

[35] F. Prestes Maia: Estudo de um plano de avenidas para a cidade de São Paulo, São Paulo, 1930. This work contains many comparisons with other cities of the world and constitutes a valuable reference in the field of urbanism.

# RECENT MAJOR OCEANOGRAPHIC EXPEDITIONS

## A REVIEW OF THE WORK OF THE METEOR, CARNEGIE, DANA, AND SNELLIUS EXPEDITIONS

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NOTWITHSTANDING the progress which has characterized oceanography since the great *Challenger* expedition of 1872–1876, only the merest beginning has been made in the study of the open sea. Even with regard to such simple features as depths, deposits, and currents is this true. Extensive areas, covering thousands of square miles, have never been sounded; the exact nature of oceanic deposits is still problematic, since the bottom has been merely scratched and in but relatively few places; the variations to which the different ocean currents are subject, especially within the depths, are almost wholly unknown.

The paucity of our knowledge of the open sea arises primarily from the fact that an oceanographic expedition of wide scope is a costly undertaking, since it necessarily involves a considerable period of time, a relatively large personnel, expensive specialized apparatus, and a well-equipped vessel. Such an expedition is altogether beyond the means of the individual oceanographer, requiring the sponsorship of some governmental agency or the resources of a well endowed institution.

The need for extensive oceanographic research, however, has become more and more urgent and in the last decade has aroused world-wide discussion. At the meeting of the British Association for the Advancement of Science held at Cardiff in August, 1920, a resolution was adopted urging the initiation of a national expedition for the exploration of the ocean similar in character to that of the *Challenger* expedition. A memorandum drawn up[1] estimated the cost of the proposed expedition at more than a million dollars, apart from the vessel, which it was hoped would be provided by the British Admiralty. Widespread interest was aroused, not only in Great Britain but throughout the world. Financial considerations, however, necessitated the abandonment of the project.

In the United States a similar discussion was brought to a head at a conference on oceanography convened by the Secretary of the Navy at Washington in July, 1924.[2] But, like the proposed British expedition, this plan for an American national expedition was never carried into execution.

In the two wealthiest maritime countries it was thus found impossible to launch a program of oceanographic research of a national character. Fortunately, however, such projects were found to be within the means of Germany, Denmark, Holland, and the Carnegie Institution of Washington. To a review of the work of these four expeditions the present article is devoted.

### The Meteor Expedition

This expedition, under the title of "Deutsche Atlantische Expedition auf dem Forschungs- und Vermessungsschiff *Meteor*" was a German national undertaking

[1] *British Assn. for the Advancement of Sci., Rept. 89th Meeting, Edinburgh, 1921*, London, 1922, pp. xix–xxii.

[2] *Geogr. Rev.*, Vol. 15, 1925, pp. 312–313.

which carried out a comprehensive oceanographic survey of the South Atlantic Ocean during a two-year period 1925–1927. Planned by Dr. Alfred Merz of the Oceanographic Institute of the University of Berlin, its leader, the expedition sailed in the *Meteor* under the command of Captain (now Rear-Admiral) Fritz Spiess of the German Navy. Upon the death of Dr. Merz in August, 1925, the leadership devolved upon Captain Spiess. The ship was a half-completed gunboat which after the war was converted into a research and survey vessel, having a length of 220 feet and a displacement of 1200 tons.

The *Meteor* expedition marks a new stage in oceanography. Heretofore, oceanographic expeditions were either of the nature of reconnaissance cruises or were devoted to the study of some restricted region or some special problem. Merz's plan, however, comprehended no less than the systematic study of a whole ocean basin. The principal aim in view was to secure observations that would permit a determination of the circulation in the South Atlantic, both horizontal and vertical. All factors entering into this complex problem were to be studied quantitatively. To carry out this purpose the ship was fully equipped with modern oceanographic instruments and carried a complement of ten scientists, a score of scientific assistants, ten officers, and a crew of nearly a hundred men.

On this expedition the *Meteor* cruised more than 67,000 miles. Fourteen profiles between Africa and South America, extending from latitude 20° N. to latitude 60° S., were investigated systematically, 310 stations being occupied. The wealth of observational material obtained may be briefly summarized as follows: 67,000 sonic soundings; 9000 temperature and salinity determinations; 7000 determinations of oxygen content and hydrogen ion concentration; 4000 determinations of phosphates and 1400 water samples for the determination of gold and silver content; 400 bottom samples; 100 stereophotographs of waves. Plankton investigations and evaporation studies were made over the entire region, and at 10 stations the ship was anchored in deep water for periods up to 48 hours for the purpose of measuring the current. And, since the vessel touched at places only infrequently visited, opportunities were afforded for miscellaneous geographic, hydrographic, meteorologic, geologic, chemical, physical, and biological observations, which were duly made.

A number of interim studies and reports on various phases of the expedition's work have appeared. Indeed, in 1929 Thorade[3] listed and discussed briefly no less than seventy such publications. Only one of these will be noticed here, namely, Captain Spiess's narrative account.[4] This volume of 376 pages illustrated by more than four hundred diagrams and photographs recounts the story of the expedition—of the preparations and difficulties encountered, of the ship and its equipment, of the scientific aims and labors. The last two features are handled very skillfully, for while the volume is popular in appeal it nevertheless embodies a surprisingly large amount of oceanography. The last chapter gives a résumé of the observational data secured and some of the tentative conclusions resulting therefrom. Quite apart from the definite information this wealth of material will give of the oceanography of the South Atlantic, new viewpoints are already resulting. As Captain Spiess notes, the sonic-sounding profiles definitely dispose of the concept that the relief of the sea bottom is monotonous; the temperature and salinity observations show no such gradual decrease with depth as has generally been accepted, for these indicate a fourfold stratification of the waters of the South Atlantic. The chemical data aid not only in securing a comprehensive view of the circulation within this basin but allow also the determination of the age and origin of the different water masses. The bottom samples permit definite orientation with regard to the distribution of the various sediments.

[3] Hermann Thorade: Vorläufige Ergebnisse der Deutschen Atlantischen Expedition auf "Meteor," *Petermanns Mitt.*, Vol. 75, 1929, pp. 65–69.

[4] Fritz Spiess: Die Meteor-Fahrt: Forschungen und Erlebnisse der Deutschen Atlantischen Expedition 1925–27, Berlin, 1928.

Captain Spiess makes it clear that the personnel of the *Meteor* realized that this was not only a scientific expedition but that it marked also the first visit of a German naval vessel in the waters of its former enemies since the World War. He stresses the political importance of this expedition and notes with appreciation the warm welcome extended everywhere. In this connection his accounts of visits made to German settlements in South Africa and in South America are especially interesting.

Of the definitive scientific reports of this expedition, the first volume[5] has recently appeared. This is a quarto volume of 442 pages, accompanied by 18 separate charts and illustrated with more than a hundred photographs and diagrams, which gives a full account of the plan of the expedition, the ship and its equipment, and a general account of the cruise and the work. It includes, in addition, a report on magnetic observations by the late K. Hessen and experiences with wireless by H. Maurer; a report on experiences with the machinery of the ship by J. Nixdorff; and a medical report by Dr. K. Kraft, the surgeon of the expedition. The thoroughness with which the different subjects are handled may be exemplified by the mere enumeration of the topical headings of the 40-page medical report: hospital facilities, living and working quarters, choice of expedition's personnel, guide for the medical service, diseases, food, special duties of an expedition's surgeon.

A foreword states that the scientific reports are to appear in sixteen volumes under the direction of Dr. Albert Defant of the Institut für Meereskunde at Berlin. Volumes 2 and 3 will cover the soundings, morphological profiles, and geology. Volumes 4 to 7 will discuss the oceanographic features, including methods and instruments, thermo-haline structure of the Atlantic Ocean, circulation problems, evaporation, and stereophotographic observations on waves. Volumes 8 and 9 will treat of the chemistry of the sea—methods and results, oxygen, nitrogen, carbonic acid, nutrient materials, and precious metals. Volumes 10 to 12 will be devoted to biology and more especially to the methods and results of quantitative and qualitative plankton investigations. The last three volumes will cover the meteorologic work—methods and results of pilot balloon and kite observations, stratification and general circulation of the atmosphere. If the work is completed on the lines of the first volume, the whole will indeed be a monumental piece of work.

## The Carnegie Expedition

In May of 1928 the *Carnegie*, the nonmagnetic ship which the Department of Terrestrial Magnetism of the Carnegie Institution of Washington had built for use in its magnetic surveys of the oceans, left Washington for a three-year cruise that was to cover all the oceans. The six previous cruises of the vessel were devoted almost wholly to the study of the earth's magnetism and electricity. On this seventh cruise, in addition to the magnetic work, an extensive program of oceanographic research was included. A party of eight scientists, under the leadership of Captain J. P. Ault, commander of the *Carnegie*, and a complement of seventeen sailing officers and crew comprised the total personnel.

The oceanographic program contemplated sonic soundings, observations on temperature and salinity, bottom samples, and determination of phosphates, silicates, oxygen, and hydrogen ion concentration. In addition, the plankton in the upper 100-meter layer of the open sea was to be investigated, and special problems in atmospheric circulation over the ocean were to be studied, especially measurements of the rate of evaporation and balloon soundings of the upper air. For a year and a half the work progressed, and then disaster overtook the vessel. In November, 1929, while she lay at anchor at Apia, western Samoa, a gasoline explosion occurred,

[5] Fritz Spiess: Das Forschungsschiff und seine Reise (Wissenschaftliche Ergebnisse der Deutschen Atlantischen Expedition auf dem Forschungs- und Vermessungsschiff "Meteor" 1925–1927, Vol. 1), Berlin and Leipzig, 1932.

which destroyed the vessel and took the life of its commander. About half of the projected cruise had been completed, the vessel having sailed 45,000 miles, covering the North Atlantic, the North Pacific, and the eastern part of the South Pacific.

During a call at San Francisco in the summer of 1929, a Meinesz pendulum apparatus was installed on board the *Carnegie*. This apparatus has been used with success on submarines; but its installation on the *Carnegie* marked the first attempt at systematic gravity observations on the open sea in a surface ship. Three stations were successfully occupied with this pendulum apparatus before the loss of the vessel, and valuable information was secured in adapting it to use on surface ships.

The policy adopted, requiring that data secured were to be forwarded promptly from each port of call to the Department of Terrestrial Magnetism at Washington, preserved from loss the observations that had been made by the vessel. As a result a large body of oceanographic data is at hand which will aid in throwing further light on the distribution of temperature and salinity and on the circulation in the North Atlantic and in parts of the Pacific Ocean. In the latter ocean modern observations have been wanting, and the *Carnegie's* work will be especially valuable. The definitive scientific reports are in preparation and are to appear in the near future.

The narrative account of this expedition has recently appeared,[6] written by Dr. Paul, who served as surgeon and also as one of the scientific observers. In some 300 pages illustrated with nearly 200 photographs an exceedingly interesting account of the expedition is given, including a description of the vessel, the world's only seagoing nonmagnetic laboratory, and its scientific equipment. The narrative of the cruise is interspersed with descriptions of many out-of-the-way places, peoples, and customs.

A number of interim reports on the work of this expedition have appeared. Among these, as of special oceanographic interest, may be mentioned F. M. Soule's paper on "Oceanographic Instruments and Methods,"[7] which gives a comprehensive description and discussion of the instruments and methods used in present-day oceanographic research, based in large part on actual use during the last cruise of the *Carnegie*, and Sverdrup's two papers dealing respectively with the Peruvian Current[8] and with the origin of the deep water of the Pacific Ocean.[9] In the former paper Sverdrup shows that the Peruvian Current—the most prominent current in the southern hemisphere—is relatively shallow, extending only about 400 meters from the surface. In the latter paper he concludes that the deep water of the Pacific originates in the eastern part of the Indian Antarctic Ocean. He finds corroboration for this in the oxygen-content determinations made by the *Carnegie*, which show the deep waters of the Pacific to be poorer in oxygen than the corresponding waters in the Atlantic.

## The Dana Expedition

The *Dana* Expedition, officially known as the "Carlsbergfondets oceanografiske Ekspedition omkring Jorden 1928–1930 under Ledelse af Professor Johannes Schmidt," was supported by the Carlsberg Foundation, Denmark's largest scientific fund. The *Dana*, the research ship of the Ministry of Marine, is a small vessel about 145 feet in length and of 360 tons displacement, which was placed at the

[6] J. Harland Paul: The Last Cruise of the Carnegie. Baltimore, 1932.

[7] N. H. Heck and Others: Physics of the Earth—V: Oceanography, *Bull. Natl. Research Council No. 85*, 1932, pp. 411–441.

[8] H. U. Sverdrup: Some Oceanographic Results of the *Carnegie's* Work in the Pacific—the Peruvian Current, *Trans. Amer. Geophys. Union, Tenth Ann. Meeting, April 25 and 26, 1929; Eleventh Ann. Meeting, May 1 and 2, 1930*, Washington, 1930, pp. 257–264.

[9] H. U. Sverdrup: The Origin of the Deep-Water of the Pacific Ocean as Indicated by the Oceanographic Work of the *Carnegie*, *Gerlands Beiträge zur Geophysik*, Vol. 29, 1931, pp. 95–105.

disposal of the expedition by the Danish Government and staffed by officers of the Royal Navy.

Its leader, Professor Schmidt is known especially for his outstanding work in elucidating the life history of the fresh-water eels of the Atlantic Ocean. To extend this work to the entire sea was the principal aim of the expedition—to complete the study by an investigation of the fresh-water eels of the Pacific and Indian Oceans. Oceanographic observations, however, constituted a large part of the program, since these are of importance in arriving at an understanding of the factors involved in the actual distribution of the different species and genera of the eels in the three oceans.

With a personnel numbering twenty-six, including scientists, officers, and crew, the *Dana* left Copenhagen in June, 1928, and returned home in June, 1930. The cruise was to cover the tropical parts of the Pacific and Indian oceans; and, because of the small coal-carrying capacity of the ship, the westward route was chosen to take advantage of the prevailing trade winds. From Copenhagen the *Dana* first steamed for the Strait of Gibraltar and thence proceeded across the Sargasso Sea and through the Panama Canal to the Marquesas, Samoa, New Caledonia, New Zealand, and Australia. From Australia the route lay north through Torres Strait and the Banda, Celebes, and China seas to Siam and Shanghai. Steaming south again the *Dana* made for the Indian Ocean—for Java, Sumatra, Cocos Islands, Ceylon, Seychelles, Madagascar, and Mombasa on the east coast of Africa. The route then lay southward along the coast of Africa, around the Cape of Good Hope, northward into the Mediterranean, and thence back to Copenhagen. The expedition's field of operations thus covered not only the three oceans but a number of the principal seas. In all some 65,000 miles were covered, 8000 sonic soundings made, and more than 4000 deep-sea water samples secured, in addition to the biological hauls and observations.

In a paper in *Nature*,[10] Professor Schmidt and Mr. Helge Thomsen give a brief résumé of the work of the expedition, Schmidt dealing principally with the biological studies, while Thomsen discusses the oxygen content in the tropical part of the Pacific. From the Gulf of Panama westward to Tahiti there is a layer of water, at a depth of about 500 meters, that is characterized by low oxygen content, a fact indicating that at this depth the currents with a meridional component must be very weak.

The final scientific reports of the expedition are to be published in some universal language. Meanwhile there has appeared an exceedingly interesting narrative account of the expedition by Dr. Schmidt and a number of collaborators.[11] In some 360 pages illustrated with a map and with more than 270 diagrams and photographs and written in popular style, it gives an account of both the scientific labors and of the less formal aspects of the cruise. Professor Schmidt contributes the introductory chapter, outlining the preparations and aims of the expedition, and four more, among which that reviewing the Danish eel investigations during the past quarter century merits special mention.

In keeping with the national character of the expedition, the Danish Ministry of Foreign Affairs supplied two sets of films depicting life in Denmark and in the Faeroes, which were shown in numerous places at which the *Dana* stopped. The expedition thus served as a messenger of good will not only to foreign countries but more especially to Denmark's children domiciled in the far-away places visited by the *Dana*. Quite apart from the scientific information embodied, the descriptions of interesting places visited in many out-of-the-way corners of the earth make this record of the expedition a valuable publication.

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[10] Oceanographical Expedition of the *Dana*, 1928–1930, *Nature*, Vol. 127, 1931, pp. 444–446 and 487–490.

[11] Johannes Schmidt: Dana's Togt omkring Jorden 1928–1930, Copenhagen, 1932.

### The Snellius Expedition

The *Snellius* Expedition was planned jointly by the Society for Scientific Research in the Dutch Colonies and the Royal Geographical Society of Amsterdam, with substantial state aid. The East Indian government placed at the disposal of the expedition the newly built surveying ship *Willebrord Snellius*, a vessel 200 feet in length and of 1200 tons displacement built for survey duty in the Dutch East Indies and thus especially well adapted for oceanographic investigations in the tropics. Staffed by naval officers, it carried in addition three oceanographers, a chemist, a geologist, and a botanist, the leadership devolving upon Commander P. M. van Riel, Chief of the Oceanographical Department of the Royal Dutch Meteorological Institute.

The field of operations covered the waters of the East Indian Archipelago lying to the eastward of Java and Borneo. This region, which separates the continental land masses of Asia and Australia and unites the Pacific Ocean with the Indian, is oceanographically most interesting. Here are found a number of individual seas with steep coasts and with depths up to 7000 meters. The seas are separated from the oceans and from each other by ridges or sills which permit the waters within their basins to develop oceanographic features of a local nature. Geologically too, the area is interesting, for the gravity researches made here on board a submarine by Vening Meinesz show it to be a region of strong gravity contrasts.

Beginning in July, 1929, the *Snellius* continued its investigations for sixteen months, during which time it cruised more than 33,000 miles. The observations were made primarily for the purpose of acquiring data with regard to the configuration and character of the sea bottom, the water exchange between the deep basins and the oceans, and with regard to the chemical and physical characteristics of the water. In addition, biologic, meteorologic, and geologic observations were made. The region investigated covers an area of about a million square miles, and over this a number of profiles were laid, the soundings totaling 32,000. At 371 stations more than 10,000 serial temperature and salinity determinations were secured from various depths. Several thousand determinations of oxygen content, phosphates, alkalinity, and hydrogen sulphide were made. At eight stations the ship was anchored and current measurements made at various depths up to 3000 meters. The bottom samples, of which 282 were secured, are especially interesting, for this expedition secured samples with a length of more than two meters. To the *Snellius* is also to be credited a sample of the bottom from a depth of more than 10,000 meters.

At the present time only preliminary reports of this expedition are available. Of these we may note here, as being most comprehensive, a recent paper by the leader.[12] In this, Commander van Riel reviews briefly the work of the expedition and discusses some of the results, more particularly the questions of the interchange of water between the seas and the oceans, the stability relations of the water masses in the various basins, the circulation in the upper layers, and the current observations.

The interchange of water between the seas and ocean constitutes a question of primary oceanographic interest in this region. Since the depths over the ridges separating these seas from the oceans differ, the temperature and salinity conditions at the same depth within the different basins show decided differences. Commander van Riel illustrates this by a diagram showing five contiguous basins whose sub-

[12] P. M. van Riel: Ozeanographische Forschung in Niederländisch-Ostindien, *Zeitschr. Gesell. für Erdkunde zu Berlin*, 1932, pp. 208–225.

The inception of the expedition was described by J. Luymes in "De Snellius-Expeditie," *Tijdschr. Kon. Nederl. Aardrijksk. Genoot.*, Ser. 2, Vol. 48, 1931, pp. 181–199. (See also "Short Sketch of the Progress of Oceanography and of the Expedition of the Royal Dutch Vessel 'Willebrord Snellius,'" *Hydrogr. Rev.*, Vol. 7, 1930, pp. 142–160.) For reports of progress see *ibid.*: Vol. 46, 1929, pp. 530–536; Vol. 47, 1930, pp. 29–47; 380–399; 708–717; 801–812; 991–1005; Vol. 48, 1931, pp. 181–199.

surface waters are fed either directly or indirectly from the Pacific Ocean. At the depth of 3000 meters the temperatures in the different basins vary from 1.81° C. to 3.23°, the determining factor being the depth over the sills of the basins.

The temperature, salinity, and current observations together with the chemical determinations contribute not only to the knowledge of the physical and chemical conditions of these waters but permit also an understanding of the dynamic processes going on. The numerous sonic soundings will permit a much more accurate delineation of the bottom relief than was possible heretofore. In the Banda and Ceram seas important ridges have been found that were previously unknown. Soundings made in the vicinity of the greatest known depth, that discovered by the *Emden* in 1927, developed this area further. The full reports of this expedition will constitute a very important contribution to the oceanography of this hitherto but little known region.

*Postscript.* As this article goes to press announcement is received of the death of Dr. Johannes Schmidt, leader of the *Dana* expedition, in Copenhagen on February 22.

# THE GUATEMALA-HONDURAS BOUNDARY

THE long-standing boundary dispute between Guatemala and Honduras has been finally settled by an award signed in Washington on January 23, 1933, by the members of a Special Boundary Tribunal appointed in accordance with the terms of a Treaty of Arbitration entered into by the two countries on July 16, 1930, and consisting of Chief Justice Hughes as president, Luis Castro Ureña of Costa Rica, and Emilio Bello Codesido of Chile (see Guatemala-Honduras Special Boundary Tribunal, Opinion and Award, Washington, D. C., 1933). The award is a particularly interesting one, not only because it settles one of the three last-remaining Hispanic-American boundary disputes of major importance (the two others still remaining to be settled being the Bolivia-Paraguay and Peru-Ecuador disputes) but also because the methods employed in studying the question and the factors that were considered in arriving at the decision might well be recommended as a pattern for the settlement of other boundary disputes of similar nature.

## The Economic Survey of 1919

The geography and resources of the region under dispute and the character of its settlement and economic development were rather better known when the dispute came up for final settlement than has been the case in most of the disputed areas in Hispanic America. In 1919, when a rather serious crisis in the dispute had developed, an economic survey of the region was carried out under the supervision of the American Geographical Society for the United States Department of State with funds supplied by the two countries, and in addition to a general report by the director of the survey, Major Percy H. Ashmead, a report was made on forest conditions in the region by H. N. Whitford and L. R. Stadtmiller, a botanical report by Henri Pittier and Sidney F. Blake, and a report on soils, agriculture, and climate by C. F. Marbut and Hugh H. Bennett.

The region as a whole is very sparsely populated in spite of the fact, as reported by the Economic Survey of 1919, that from eighty to ninety per cent of it is suitable for crops or grazing; the total population estimated for an area of 4615 square miles examined by the Survey being not more than 24,000. A large part of the area is heavily forested with pine and tropical hardwoods that have been little exploited except for local use. Some gold has been found in various parts of the region, the most important placer operations being at Las Quebradas in the Motagua Valley. Bananas, of which some 60,000 acres bordering the Motagua River from Tenedores to beyond Los Amates and along the Cuyamel Railway were under cultivation when the Economic Survey was made, are the only commercially important crop of the region. Elsewhere the agricultural population, which is concentrated chiefly in small villages, lives the self-contained existence with little or no outside commercial contacts characteristic of much of the agricultural population of Hispanic American countries.

The oldest section of the disputed region from the standpoint of settlement is that which extends northward from the boundary with El Salvador to the point where the new boundary crosses the Managua River. There many of the land titles date from colonial grants made by either the province of Guatemala or that of Honduras of the Kingdom of Guatemala, which comprised in addition to these provinces the territories now pertaining to Nicaragua, El Salvador, and Costa Rica. The section eastward from the Managua River was little known and almost completely unexplored previous to the War of Independence, and the settlements and land grants there are of com-

paratively recent date. In fact very little importance seems to have been attached to it by either country until banana raising on a commercial scale was found to be profitable there. In the whole of the region claimed by both countries overlapping land grants were found by the Economic Survey of 1919 to amount to only 178 square miles and about 40 miles of railroad right of way.

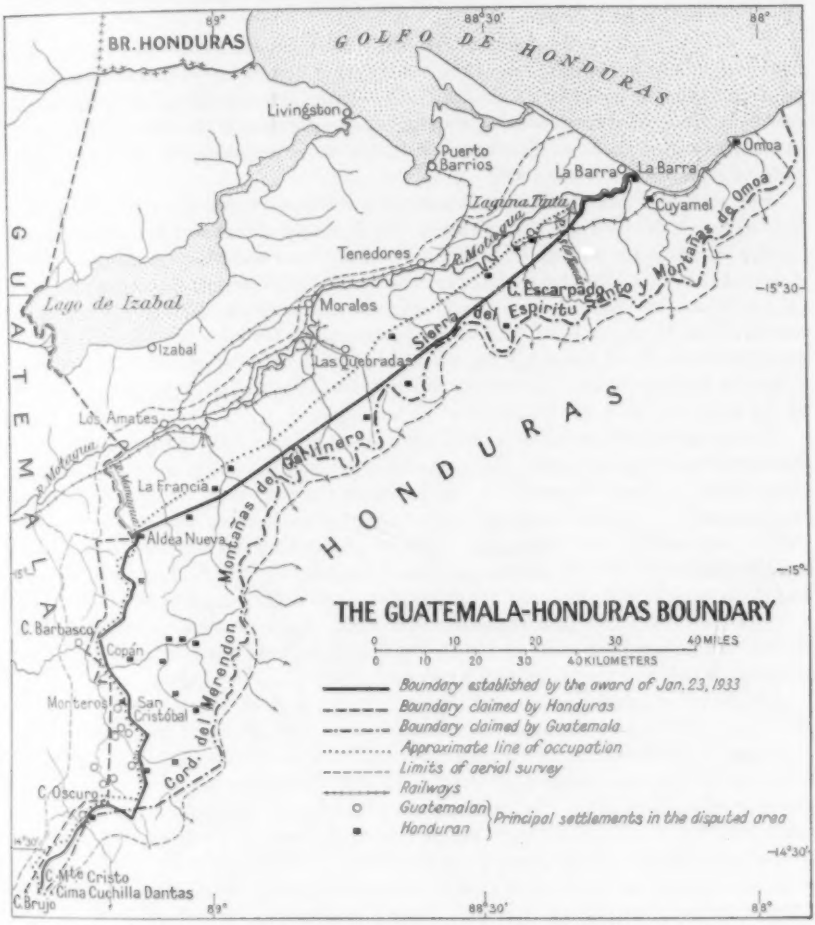


FIG. 1—Map illustrating the boundary dispute between Guatemala and Honduras with the settlement of 1933. Scale 1 : 1,450,000.

## THE UTI POSSIDETIS OF 1821

As in practically all boundary disputes in Hispanic America the claims of both countries to the territory under dispute were based on their respective interpretations of the administrative limits, at the moment of independence, of the colonial entities which, at the close of the Wars of Independence, became separate and independent republics. By the terms of the Treaty of 1930, therefore, the first task before the Special Tribunal was to determine (or at least to attempt to determine) the location of the line which at the moment of independence separated the provinces of Guatemala and Honduras in the Kingdom of Guatemala, that is the line described in the treaty as the line of the *uti possidetis* of 1821. Difficulties arose at once as to what was meant

by the *uti possidetis* of 1821; Guatemala interpreting it as meaning a line drawn in conformity with the facts of actual possession, whereas Honduras interpreted it not as a *uti possidetis de facto*, as claimed by Guatemala, but as a *uti possidetis juris*, that is, as a line determined by the territory that the two provinces, at the moment of independence, had a right to possess according to decrees of the Spanish crown and not by such territory as they might have taken possession of and administered beyond the limits set by such decrees.

It was decided by the Special Tribunal, however, that the term *uti possidetis* could refer only to an administrative control that rested in the will of the Spanish crown and that it could be established only where there was actual documental evidence, in the form of royal *cédulas*, orders, laws, or decrees, of the will of the crown or, in the absence of these, evidence by conduct of royal acquiescence in colonial assertions of administrative authority.

For study and discussion the boundary zone was divided by the Tribunal into four sections: (1) The territory between the Motagua River and British Honduras; (2) the Omoa-Cuyamel area (that is the town of Omoa and the region contiguous to it bounded by the Mountains of Omoa, the Tinto and Motagua rivers, and the sea); (3) the Motagua Valley from a point near the mouth of the Managua River to the mouth of the Motagua River and including the region between the Motagua and the main water divide of the range known as Montañas del Gallinero o de la Grita and Sierra del Espiritu Santo; and (4) the territory from the mouth of the Managua River to the boundary with the Republic of El Salvador.

It was found that the *uti possidetis* could be established only in the last-mentioned section where it was defined by the Tribunal on the basis chiefly of colonial land grants as beginning at Cerro Montecristo and following the Quebrada de Tecompampa and the Quebrada de la Brea to the parallel of Cerro Oscuro, along that parallel to Cerro Oscuro, and thence, with a few gaps where no satisfactory evidence of administrative control during the colonial period was found, to Cerro Barbasco. Elsewhere not only was there no sufficient documentary evidence submitted by either country to establish its claim as to the limits of colonial administration, but no evidence was found, owing chiefly to the fact that most of the region in dispute was unsettled and largely unexplored in colonial times, on which any such limits could be based.

On the other hand it was found that, whereas no evidence was submitted to substantiate the Honduran claim to territory between the Motagua River and British Honduras, satisfactory evidence was submitted by Guatemala that its claim to that territory was in accordance with conditions that had prevailed prior to and at the moment of independence. In studying the Omoa-Cuyamel region it was found that some years prior to the granting of independence the town of Omoa had been removed from the jurisdiction of the province of Honduras and held by the Kingdom of Guatemala as a military station for the kingdom as a whole and could, therefore, be properly considered as belonging to Honduras once the kingdom had ceased to exist. No evidence was presented, however, as to the possession of the contiguous Cuyamel region by either country prior to their independence; but, in view of the fact that, since 1832, Honduras had been in possession of the greater part of the region with evident acquiescence on the part of Guatemala until recent years, it was decided that the boundary line should be along the Rio Tinto from the point where it leaves the Laguna Tinta to its mouth on the Motagua and thence along the right bank of the Motagua to the sea; the lower Motagua having, at some time since 1821, left its old channel for that of the lower Tinto.

## The Final Boundary Award

Between Laguna Tinta and the point where the boundary leaves the Managua River the boundary was so located as to assign to each country such properties as had long been under their unopposed jurisdiction. It will be noted on the map that

the course of the boundary in this section assigns to Guatemala not only lands held by the Cuyamel Fruit Company and others under concession from the Honduran government but also the section of the Cuyamel Fruit Company's railway west of the Santo Tomas River. It would appear that this decision might work considerable hardship to the concessionaires and involve Guatemala in protracted adjustment proceedings. The westward extension of the railroad, however, was built during the World War and was permitted by Guatemala only because of the interest manifested by the United States government in the expansion of banana cultivation as a contribution to the food supply needed for the prosecution of the war and with the express understanding that it would not be introduced in connection with the settlement of the boundary dispute. Moreover, it was found that the banana plantations west of the Santo Tomas River had been largely abandoned on account of disease and that that section of the railway was only operated sufficiently to maintain the franchise.

From the point where it crosses the Managua River to the boundary of El Salvador the boundary follows very closely the line of actual occupation as determined by a joint commission of engineers in 1910, by the Economic Survey of 1919, and by the engineers who during the summer of 1932 supervised an aerial survey of the boundary zone for the Special Tribunal.

## Maps Used By the Special Tribunal

As a base map for its studies the Special Tribunal chose the map compiled at the American Geographical Society in 1919. This map was reproduced on the scale of 1:200,000 from the original drawings on the scale of 1:100,000 and used for plotting the rival claims and for examining the various sections into which the territory in dispute was divided for study.

To geographers and cartographers one of the most interesting features of the work of the Special Tribunal is the preparation of the map on which the final decision was plotted and which is attached to the award. During the summer of 1932, at the request of the Tribunal, aviators and photographers of the United States Army Air Corps operating under the supervision of Mr. Sydney H. Birdseye made an aerial survey by means of vertical photographs of the boundary zone as far north as and including the Motagua River. No ground control was established for this survey, but a map was compiled from it by adjusting the details from the vertical photographs to the American Geographical Society's map. The resulting map, together with the photographs used in compiling it, was used by the Tribunal for its final deliberations, and on it was plotted the boundary award. While the map is without contours, it shows rivers, settlements, and roads in such detail that when a joint commission enters the field to demarcate the boundary it should be able to follow the course of the boundary as defined by the award with none of the difficulties that usually attend the interpretation of boundary treaties on the ground.

# TWENTY-NINTH ANNUAL MEETING OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS

THE Association of American Geographers met at Washington, D. C., on December 28, 29, and 30, 1932, for its twenty-ninth annual meeting. The sessions were held in the new Shoreham Hotel, with Dr. O. E. Baker, of the Bureau of Agricultural Economics, President of the Association for 1932, in the chair. As the hotel, which is pleasantly located in the northwestern outskirts of the city overlooking Rock Creek valley, also served as headquarters, there was no need to leave the shelter of its roof—an advantage enlarged by the inclement weather to outweigh the lack of privacy and professional atmosphere that made itself felt to a certain extent in the rooms in which the papers were read.

## Government Bureau Exhibits

The professional touch, however, was fully apparent in the arrangements the local members had made to acquaint their colleagues with the activities of the institutions with which they are associated. These took the form of exhibits prepared by the various government bureaus whose work is geographical in character. How large a share this work represents of the research carried out by members of the Association is evident from the fact that in spite of the growth of modern geography in the universities since the foundation of the Association, when government investigators formed its nucleus, the Washington members still number nearly twenty per cent of the total membership.

The establishments of the federal government that had exhibits were the Coast and Geodetic Survey, Geological Survey, Soil Survey, Weather Bureau, Bureau of Agricultural Economics, Bureau of the Census, Bureau of Foreign and Domestic Commerce, the Office of the Geographer of the Department of State, and the Division of Maps of the Library of Congress. Unfortunately only two hours were available on the afternoon of December 29 to visit the exhibits, several of which, such as that of the Geological Survey, had been prepared with as much care as if they were to be placed in a national or international exposition. It is of interest to note that the recent work of both the Geological Survey and the State Department has involved the consultation of geographers in the attempt to arrive at reasonable boundary decisions, in the former case with regard to the recent arbitration of the Guatemala-Honduras boundary and in the latter in connection with the recent treaty between the United States and Great Britain relating to the water boundary between the Philippines and British North Borneo. The original of this treaty was on display at the State Department as well as the original of the Treaty of Guadalupe Hidalgo which terminated the Mexican War.

Of the latter treaty the accompanying "Map of the United Mexican States" on the scale of 70 miles to the inch published by John Disturnell, New York, 1847, forms an integral part and was likewise an exhibit. Those familiar with the early history of the American Geographical Society will recall that the first step in the organization of the Society was taken in Disturnell's "Geographical Rooms" at 102 Broadway, on October 9, 1851 (*Bull. Amer. Geogr. and Statist. Soc.*, Vol. 1, 1852, p. 3) and that Mr. Disturnell was appointed Secretary and Agent of the Society. In view of this association it is not surprising to find that the copy of the map in the Society's collection bears additions in manuscript, apparently in the handwriting of J. Calvin Smith,

relating to the treaty negotiations, especially those concerning the southern boundary of the territory to be ceded by Mexico as proposed by the Mexican commissioner (37th parallel) and as proposed by Calhoun (32nd parallel) and the true position of El Paso, the uncertainty about which affected the delineation of the boundary in the southwestern corner of what is now New Mexico (E. M. Douglas, *U. S. Geol. Survey Bull. 817*, Washington, 1930, p. 38 and Fig. 22).

At the Division of Maps of the Library of Congress a map exhibit had been arranged that gave an insight into the scope of that collection and presented some of its treasures. These included various editions (1755–1791) of John Mitchell's "Map of the British and French Dominions in North America," termed the most important map affecting the history of the United States inasmuch as it was used in the negotiations that led to the treaty of peace of 1783; four previously unidentified maps by Lewis Evans of Philadelphia, author of the well known "General Map of the Middle British Colonies in America," 1755; manuscript maps by George Washington and John Muir, the latter group showing Alaskan fiords and glaciers; samples of some of the 400,000 large-scale fire insurance and real estate maps of cities of the United States in the collection, representing the American equivalent of European cadastral surveys and constituting a prime, and often the only, source for the representation of the built-up area in our urban centers; and examples of the Library's wide range of Chinese and other Oriental maps.

On December 29 the members of the Association were the guests of Mrs. Albert Perry Brigham at luncheon in the Library of Congress. Mrs. Brigham, who was absent in Italy, had also generously arranged that each member should receive, in memory of her husband, a complimentary copy of Professor Brigham's "Cape Cod and the Old Colony." On the preceding evening the members were entertained by the National Geographic Society. They were conducted through the group of buildings forming the headquarters of the Society (see *Natl. Geogr. Mag.*, Vol. 15, 1904, pp. 176–181, and Vol. 25, 1914, pp. 455–470) by members of the staff and shown through the working offices, including the photographic laboratories and the map drafting rooms.

## Papers on Settlement and Land Utilization

In all, twenty-seven papers exclusive of the President's address and five memorials to deceased members were read. Twelve of these papers were by persons introduced by members. Although the papers naturally fall into five or six major topical groups the program as a whole lacked some of the coherence that is imparted by planned concentration on a major theme for part of the session through solicited papers.

Five papers dealt with phases of rural and urban settlement. R. B. Hall continued his discussion of rural settlement forms in Japan, begun at the Columbus meeting (*Geogr. Rev.*, Vol. 20, 1930, p. 306), taking up, amongst others, the giant houses of the Japanese Alps region and the villages of Hokkaido. Robert S. Platt, under the title of "Mining Patterns of Occupancy in Five South American Districts," showed how the functional pattern of occupance reflects the distinctive regional environment, whether it be tin mine in the isolated Bolivian highland, gold mine in the Brazilian subtropical plateau, copper mine or nitrate oficina in the Chilean puna or desert, or oil field on the Peruvian coast, irrespective of the standardizing influence of the mining technique, which is of European or North American origin. Preston E. James's "Rio de Janeiro: A Study in Tropical Urban Geography" is published in this issue of the *Geographical Review*. Raymond E. Murphy (introduced) dealt with "The Geography of Johnstown, Pennsylvania, An Iron and Steel Center," and E. C. Prophet (introduced) contributed a "Survey of the Recreational Industry of Michigan."

The results of an important investigation undertaken by the Bureau of Agricultural Economics to classify and subdivide the United States into its optimum land

utilization areas were presented by C. P. Barnes of that Bureau under the title "Natural Land Use Areas of the United States," his paper being accompanied by a detailed map. It is of interest to note that the Bureau of the Census is engaged independently upon a related inquiry. H. H. Bennett's paper on "The Technique of the Quantitative Study of Erosion, and Some Early Results of This Study" discussed the work of the Bureau of Chemistry and Soils in the joint research undertaken with the Bureau of Agricultural Engineering and the Forest Service with regard to the processes of erosion and run-off and to the methods of control in the various major soil and climatic regions of the United States where soil washing presents a serious problem. To the field of agricultural geography also belonged Dr. O. E. Baker's presidential address, in which a masterly analysis of the problems besetting American agriculture was presented under the title "Agricultural Migration and the National Welfare."

### Population Studies

A number of papers dealt with different aspects of population in the United States and the world as a whole. C. E. Batschelet (introduced) of the Bureau of the Census spoke on "Population Trends in Selected Urban Areas" and pointed out that American cities are now dependent on their outer, annexed districts to show a population increase, the core usually decreasing or remaining stationary in number of inhabitants. This and other trends have latterly led the Bureau of the Census to establish, as a basis for its urban statistics of the major centers of population, "metropolitan districts" which, by including all the territory in which live those who daily work in the center, more correctly encompass the true population of a metropolitan agglomeration. Stanley D. Dodge presented a preliminary study of the "Population Regions of New England, with Special Reference to Areas of Decline" in which the regions were outlined in accordance with the type of population growth or decline to which they belonged as ascertained from their population curves (on this topic see maps on pp. 26–27 of "New England's Prospect: 1933," *Amer. Geogr. Soc. Special Publ. No. 16*, New York, 1933). Lester E. Klimm (introduced) of the University of Pennsylvania continued his investigation of population changes in Massachusetts begun at the Worcester meeting (*Geogr. Rev.*, Vol. 21, 1931, p. 306) in a paper entitled "The Relation Among Topography, Land Values, and Recent Immigration in Western Massachusetts." A contribution to the critical handling of census figures was made by Ella M. Wilson (introduced) of the State Normal College of Ypsilanti, Mich., in the discussion of "National Population Figures Reduced to Standard Dates."

Mark Jefferson under the title "Communication and Civilization" presented a revised evaluation of the degree of civilization of the countries of the world. Amplifying and modifying his earlier criteria (see *Bull. Amer. Geogr. Soc.*, Vol. 43, 1911, pp. 241–265) from schooling, railroads, mail, and foreign commerce to schooling, inventiveness, urbanism (extent of city development), communications (railroads, telephones, automobiles), foreign and domestic trade, he arrived at the following civilization indices for 1925 (1905 in parentheses) for the following five nations: United States 100 (79), Great Britain 75 (97), Switzerland 71 (100), Germany 51 (80), France 43 (66).

### Economic and Regional

Economic and regional geography were represented by a number of papers. J. W. Frey contributed "A Few Geographic Notes on the American Petroleum Industry," Esther S. Anderson (introduced) of the University of Nebraska discussed "The Geographic Factors in the Development of the American Sugar Beet Industry," and S. P. Poole (introduced) told of the "Oyster Culture in the Auray River of Brittany."

A group of five papers dealt with Central America and the West Indies. N. A. Bengtson, on the basis of the new light shed by recent archeological investigation,

described the present "Distribution of the Native Peoples of Central America" in terms of their early migrations. Rollin S. Atwood (introduced) described the home life and occupations of the Maya-Quiché Indians in a mountain area at the head of the Rio Grande-Motagua trench. In his paper "The Lesser Antilles, Past and Present" R. H. Whitbeck called attention to the fact that in colonial days the relatively small islands of the West Indies were more highly valued by the European Powers than such large areas on the continent as Canada and Louisiana owing to the fact they were the nearest and most accessible tropical lands available to European exploitation (absorption of slave labor, sugar production). This emphasis is still reflected in the exaggerated sense of individualism of the inhabitants of the Lesser Antilles, of which lack of administrative consolidation (even the British islands are under four distinct governmental heads) is an outward expression. W. H. Haas analyzed both the geographic and the economic factors affecting the present condition of Cuba in his paper "Climate, Soils, and Sugar in Cuba." E. B. Shaw (introduced) discussed the leading industry of the largest of the American Virgin Islands under the title "St. Croix, A Marginal Sugar Producing Land."

J. F. Bogardus (introduced) of the University of Pennsylvania spoke on North Brabant and showed how this province of the Netherlands, physically segregated through the formation of the Hollandsch Diep as the result of storm and flood in the fifteenth century, had gradually overcome its isolation and its natural orientation toward Belgium through the development of a transportation network tying it in with the north. In cameo-like portraiture Derwent Whittlesey showed how Andorra's autonomy is due, not to isolation, "rugged individualism," or other reasons of facile explanation, but to the fact that the long continuance of the balance of power between France and Spain left this unimportant pocket in the Pyrenees untouched when these two countries settled their differences in 1659. Since then Andorra's autonomy has been threatened only twice, during the French Revolution, and in the present year as the result of the opening up of the area through the completion of a motor road. In "Visibility and the Discovery of Polar Lands" (read by S. D. Dodge) W. H. Hobbs enlarged upon a theme broached in his "Wilkes Land Rediscovered" (*Geogr. Rev.*, Vol. 22, 1932).

### Physiography

Only three papers dealt with physiographic topics. William S. Cooper presented new interpretations in his paper on "The Postglacial History of the Upper Mississippi River." A series of block diagrams representing progressive stages of development illustrated "The Course of the Green River Across the Uinta Range, Utah" by W. H. Bradley (introduced). F. E. Matthes spoke on "The Committee on Glaciers of the American Geophysical Union and Its Work." The present status of geodetic surveys in the United States was outlined by William Bowie.

### Memorials

The nearly thirty years' existence of the Association is beginning to tell in the thinning of the ranks among the early members. Six died during 1932. Memorials were read of A. P. Brigham, Ellen C. Semple, F. J. Turner, W. G. Reed, and H. G. Bryant. In the obituary of Mr. Bryant it was announced that he had bequeathed $150,000 to Princeton University for a professorship of geography and $500,000 to the Geographical Society of Philadelphia.

# AMERICAN GEOGRAPHICAL SOCIETY

**The December Meeting.** The regular monthly meeting of the American Geographical Society was held on December 20, 1932, at the Engineering Societies' Building, 29 West 39th Street, President Finley in the chair. Mr. John A. Haeseler delivered a lecture on "Berber Tribes of North Africa." He described the tribes of the Aurès Massif of northeastern Algeria, who live today under conditions almost as primitive as when the country was a part of the Roman Empire. Mr. Haeseler accompanied Captain M. W. Hilton-Simpson on an expedition from the Oxford University School of Anthropology, which made an exhaustive study of the crafts and customs of these backward people. His motion pictures presented a detailed record of their life.

**The January Meeting.** The Annual Meeting of the Society was held on January 26, 1933, at the Engineering Societies' Building, 29 West 39th Street, President Finley presiding. After the reading of the Annual Report (printed below) and the election of officers for 1933 the Society was addressed by Mr. Vincenzo Petrullo on "Primitive Peoples of Matto Grosso." The tribes that inhabit the highlands of Matto Grosso, Brazil—a typical refuge area to which they have been driven by more highly cultured and aggressive tribes—are among the most primitive people known to science. In 1931 Mr. Petrullo conducted an archeological and ethnological expedition under the auspices of the Museum of the University of Pennsylvania to the section of these highlands that is drained by the headwaters of the Paraguay and Xingú rivers and made a detailed study and motion picture record of the life and customs of its inhabitants.

**The February Meeting.** The regular monthly meeting of the Society was held on February 23, 1932, at the Engineering Societies' Building, 29 West 39th Street, Vice-President Henry in the chair. Mr. Herbert C. White delivered a lecture entitled "With the Camera in an Enchanted Empire." During nearly ten years of residence in China the lecturer and his brother had opportunities for studying and photographing the country's masterpieces of architecture and landscape gardening. Their enlarged photographs, nearly 4000 in number, were painted by native artists and are remarkably faithful reproductions of the original detail and color. The lecture was illustrated by numerous colored slides reproduced from these photographs and also by an exhibition of the originals.

**Elections of Fellows.** At the December, January, and February meetings of the Society, there were presented with the approval of the Council the names of 113 candidates who were duly elected as Fellows of the Society.

**The Millionth Map of Hispanic America.** Two new sheets of the Map of Hispanic America on the scale of 1:1,000,000 in addition to those announced in the annual report published in this issue of the *Review* are now available, making a total of 44 published sheets.

The new sheets are sheets North F-12 (Colima) and South A-23 (Carinanha). The former covers all of the Mexican state of Colima and parts of the adjoining states of Jalisco and Michoacan, while the latter covers parts of the Brazilian states of Goyaz, Bahia, and Minas Geraes.

**The Bibliographie Géographique Internationale for 1931.** The forty-first issue of the *Bibliographie Géographique* is now ready for distribution in the United States by the American Geographical Society. With the present volume there has been a change in title and it is now issued as the *Bibliographie Géographique Internationale*. It is published by the Association de Géographes Français with the collaboration of the American Geographical Society, the Comitato Geografico Nazionale Italiano, the Royal Geographical Society (London), the Société Belge d'Études Géographiques, and the Société Royale de Géographie d'Égypte. The material listed is critically selected, and brief critical notes or references to reviews in outstanding geographical periodicals are added to many of the titles. Current publications—books, periodicals, government and state publications, and maps—are included.

**The Labrador Survey of 1932.** In the spring of 1932 Dr. Alexander Forbes decided to extend his aerial survey of the Labrador coast southward from Gulch Cape, the southern end of the area covered in 1931, to Port Manvers, where it would overlap the area surveyed by Wheeler (*Geogr. Rev.*, Vol. 20, 1930, pp. 454–468), which extends from the Kiglapait Mountains to the region just south of Nain.

The surveying seaplane that had been obtained for the expedition of 1931 (see Alexander Forbes: Surveying in Northern Labrador, *Geogr. Rev.*, Vol. 22, 1932, pp. 30–60) was still available, and more than half the gasoline and the lubricating oil remained unconsumed at convenient points on the coast. Furthermore, this southern area, being nearer to the sources of supply and including the Hudson's Bay Company post at Hebron, could be covered without the necessity of a supporting expedition with a large supply of fuel such as was carried in 1931. Thus at a small fraction of the expense of the previous expedition, the gap between existing surveys could be filled in and the coast covered by oblique aerial photographs from Ungava Bay to Nain.

The personnel of the expedition consisted of Harold G. Crowley, pilot, Alexander Macleod, mechanic, Edward Sturgis, Jr., photographer, and Charles J. Hubbard, surveyor. Mr. Hubbard's schooner *Zavorah* served as mother ship, carrying fuel to points where it was difficult to procure it otherwise.

On July 20 the Fairchild seaplane started north from St. Anthony. At Hopedale they were delayed by pack ice and bad weather, but on July 23, on hearing of a white man found dead far in the interior, Crowley and Hubbard, with two Indian guides, flew in 160 miles to a lake where they recovered the body, subsequently identified as that of Fred Connell, Jr., who endeavored to cross from Ungava Bay to Hopedale in 1931. The plane reached Nain on July 27 and, joining the *Zavorah* at Nutak, flew Hubbard on August 2 to Hebron, which place afforded a convenient and central location to conduct the necessary ground control operations.

The American Geographical Society provided the necessary instruments, including a Wild Universal theodolite. The ground survey was similar to that conducted the previous summer farther north, consisting of a small local triangulation from which prominent points were intersected.

Preliminary inspection of the area from the air showed two possible locations for the base line, one being northwest from Hebron at the foot of Johannaseluk—a considerable mountain—and the other northeast across the bay. Since the weather outlook promised a few days of fine visibility it was decided to use the latter and more accessible area in an attempt to complete the observations as rapidly as possible.

When the results have been worked up it is hoped that this triangulation will tie in to the control established in 1931 by reintersection from points in the vicinity of Razorback and Blow-Me-Down mountains, but at the time it was difficult to identify these mountains from the south. However, the Mugford group of peaks together with numerous prominent points in the neighborhood of Hebron and Saeglek have been connected, and in addition the local triangulation was oriented with astronomical observations for latitude, longitude, and azimuth.

While Hubbard was at work on the ground control, the seaplane carried out the photographic flights from Nutak as a base. On August 3 the entire coast line was covered, the flight extending north offshore to Gulch Cape, thence south inshore to Port Manvers, and returning offshore to Nutak—flying time, six hours. On August 4, the air being clearer than on the previous day, the flight line was repeated, and in this way two sets of photographs covering the area were taken, nearly 600 pictures in all.

On August 9 Crowley flew from Nutak to Nain to get the doctor from H. M. S. *Challenger*, Admiralty survey ship, to attend a woman seriously ill. The doctor was flown to Nutak, gave much-needed treatment, and the party returned to Nain before dark, just as the descent of the clouds to sea level was beginning to render flying really dangerous. As soon as the weather cleared again, Crowley took Captain Wyatt of the *Challenger* and his navigating officer up for a flight over the area in which they were beginning a hydrographic survey; they flew from Nain to Davis Inlet and back. In the afternoon at Captain Wyatt's request, Crowley and Sturgis made a photographic flight from a point east of Nain to a point east of Davis Inlet, photographing from two parallel lines. The pictures, 36 in number, have been sent to the hydrographer of the British Admiralty, who is planning to have a map made from them by the Canadian grid method.

On August 16 the aerial party reached Cartwright and on the 22nd flew in from Northwest River to the Grand Falls, to take both still and motion pictures of this great cataract. They camped there two days and, as they were starting back, saw smoke rising by a lake. Landing, they found three men stranded with a disabled Canadian Airways seaplane and unable to find their food cache three miles away. The cache was located from the air, one of the party was flown out to Northwest River, Canadian Airways Company was notified by radio, and on August 28 additional food was flown in to the Falls for those who had stayed with the disabled plane.

The expedition then started homeward, the Fairchild plane reaching Boston on September 1. The photographs and field observations will be worked up at the American Geographical Society as soon as the maps of the 1931 expedition have been completed.

## ANNUAL REPORT OF THE COUNCIL

January 26, 1933

*To the Fellows of the Society:*

The activities of the Society as a research institution are divided into two main categories: first, the routine work of answering inquiries from and assisting, by advice, by special training, and by our library and map facilities, a great variety of consultants whose needs are being constantly presented to the various specialists on the staff by letter, telephone, and personal visits; and, second, original research by the Society itself or in coöperation with other research institutions. The first is of such nature that only a small portion of it can find expression in the Annual Report, but it forms a steadily increasing part of the daily work of the Society as the special interests and qualifications of its staff and the character of its collections become constantly more widely known through its periodical, book, and map publications, and through those who have made use of its research facilities.

In the field of research, as will be seen from the following summary, the Society is carrying out studies of importance both in the physical field and in the relations of man to his environment.

### The Geographical Review

Aerial photography, that important new tool of geographical research, figures largely in the 1932 program of the *Geographical Review*. In "Surveying in Northern

Labrador" Dr. Alexander Forbes presents a selection of his expedition's photographs, from which a map is in process of construction by Mr. O. M. Miller of the American Geographical Society's School of Surveying (compare the Annual Report for 1931). The photographs will also prove invaluable in physiographic study. Mr. Lincoln Ellsworth, representative of the American Geographical Society on the 1931 Arctic Expedition of the *Graf Zeppelin*, and Commander E. H. Smith report on that expedition, commenting in particular on the value of the camera in recording ice conditions and on the corrections to the map made by the photogrammetric survey. Still more varied are the possibilities envisaged in Mr. Robert Shippee's articles "The Great Wall of Peru" and "Lost Valleys of Peru." His camera revealed such unsuspected features as the remarkable volcanoes of the Andagua Valley shown on a mosaic map on the scale 1 inch to 2700 feet, the "great wall" of the Santa Valley, and the curious amphitheaters of the Cuzco area.

Mr. Miller's method was also put to use in the construction of a "Map of the Heads of Kjerulf and Dickson Fiords, East Greenland" from the ground photographs taken by Miss Louise A. Boyd on her expedition of the preceding year. Here again is immensely valuable material for physiographic study. Miss Boyd's expedition reached the heads of all the fiords in the Franz Josef and King Oscar fiords region, and she secured many photographs of glacier fronts. The systematic study of glacier fluctuations has lately been brought to the fore by the creation of a Committee on Glaciers of the American Geophysical Union. One of the members of the Committee, Mr. W. O. Field, Jr., contributed to the *Review* a finely illustrated regional study, "The Glaciers of the Northern Part of Prince William Sound, Alaska." The solution of a glacial enigma in High Asia is described by Professor Giotto Dainelli in an account of his discovery of the Italia Pass in the Eastern Karakoram.

The Society's cartographic work on the Antarctic has been carried a stage further with the bathymetric map on the scale of 1 : 25,000,000 accompanying the article "Norwegian Explorations in the Antarctic, 1930–1931." The map incorporates the discoveries of the *Norvegia* and the Norwegian whalers and, as far as available, the 1930–1931 season's work of Sir Douglas Mawson's expedition. The latter expedition operated in part in the area of Wilkes's exploration of 1840. Professor W. H. Hobbs, vindicating the American explorer in "Wilkes Land Rediscovered," analyzes the situation with the aid of a large-scale map in color showing the routes of Wilkes, Mawson, and other explorers.

Events of the last eighteen months in the Far East give timeliness to Owen Lattimore's "Chinese Colonization in Manchuria"—a contribution notable for its insight into the "historical forces, which influence the affairs of the living"—and distinguish this area from other regions of pioneer settlement. A special phase of the Manchurian problem is Hoon K. Lee's "Korean Migrants in Manchuria," while another boundary of ancient strife is dealt with by Dr. P. H. Stevenson of the Peiping Union Medical College in an article on the Chinese-Tibetan borderland. Still broader in scope is Mr. C. W. Bishop's paper on "The Rise of Civilization in China with Reference to Its Geographical Aspects."

A group of papers whose theme is land utilization ranges from studies on individual farms in the Central Andes and a single valley in southern California to a major region in the Union of South Africa, a region which in its physical circumstance in particular offers scope to the nation-planner, "the geographer in action." "The Coffee Lands of Southeastern Brazil" treats of an unbalanced utilization that has led to a striking case of overproduction. Another product that has suffered from overproduction is sugar. Here the situation is brought about in part by the unusual phenomenon of direct competition between a tropical and a temperate-zone product, as is pointed out in "Geographical Trends in Sugar Production" by a member of the staff of the International Institute of Agriculture at Rome.

Studies of population distribution range from present-day changes in England,

where a pronounced southward drift is exhibited, to the study of ancient distributions by archeological methods in the case of the Eskimos of St. Lawrence Island and a pueblo people in Arizona, the latter study employing an interesting new method of dating.

New work in the field of physical geography includes the beginning of an important work on the Gulf Stream temperatures. The importance of detailed rainfall studies in marginal lands is pointed out in an article presenting a series of new rainfall maps of Nebraska.

Exploration, regional geography, city geography, and historical geography are represented. In the last-named, under the title "Sections and National Growth," a presentation is made of the plan of the "Atlas of the Historical Geography of the United States" lately published by the Carnegie Institution of Washington and the American Geographical Society, with an insert plate in color to illustrate the rich diversity of the atlas.

### Millionth Map of Hispanic America

Five new sheets of the Millionth Map were published in 1932, bringing the total of published sheets to 42. Six others are now in proof, and the fairdrawing has been completed on 7 others. A large part of the compilation work of the past year has been devoted to the Mexican sheets of the map, of which all except the Mexico City sheet are now completed. New source material received during the year consisted chiefly of road and railway surveys in Mexico, many of which were topographical surveys with close contours.

### Atlas of the Historical Geography of the United States

In October the Society, in collaboration with the Carnegie Institution of Washington, published the "Atlas of the Historical Geography of the United States" compiled by Dr. C. O. Paullin. While the larger part of the work of compiling this atlas, in which many outstanding scholars in the fields of American history and geography participated, was carried out at the Carnegie Institution, the Society added a considerable number of maps, edited the entire volume, and saw it through the press. The maps and accompanying text offer a comprehensive view of the natural environment, settlement, and political, social, economic, and military history of the country.

### Population Studies

Early in January, 1933, the Society published the results of the regional study of New England, initiated in 1929, in a volume entitled "New England's Prospect: 1933." In the twenty-nine articles by twenty-seven specialists, constituting the volume, the economic, social, industrial, and political life of contemporary New England is discussed from many points of view. In contrast with the Society's studies of pioneer regions and problems, this volume treats of the problems of a single region, homogeneous, relatively old, highly developed, and extremely complex.

### Pioneer Settlement

Under the title of "Pioneer Settlement" the Society published in 1932 a volume of papers by twenty-six authors giving first-hand information on conditions and problems in the major areas of actual or potential pioneer settlement throughout the world. This volume represents a portion of the results of the study of pioneer settlement undertaken by the Society some years ago with the coöperation and support of the Social Science Research Council. The field work in Canada, which was selected as the area best suited for initiation of the field studies, has been completed, and the results are to be published in nine volumes by the Canadian Pioneer Problems

Committee. Plans of more limited scope have been carried out in a number of regions, notably in the western part of the United States and in Manchuria and Mongolia. The Society has also made a beginning on the acquisition of printed material in the field of pioneer settlement with a view to cataloguing it in such manner as to make it most easy of access to research workers.

### Coastal Terrace Studies

Substantial progress was made during the year in the study of coastal terrace physiography, which is being carried out in coöperation with the Carnegie Institution of Washington and Columbia University under the leadership of Professor D. W. Johnson of Columbia University. Detailed surveys in the Connecticut Valley and along the lower Susquehanna River, made for the specific purpose of settling disputed questions of fact, have not only shed much light on the causes of divergent conclusions but have also contributed materially to our knowledge of possible variations in terrace form and structure and of the extent to which terraces in stream valleys may be expected to indicate changes in sea level. A number of areas, including a small section in Connecticut and extensive sections of the Maryland-Virginia Piedmont, were selected for study by means of closely-spaced projected profiles with a view to restoring the dissected upland surfaces in order that a detailed analysis might be made of terrace forms nearly destroyed by erosion. These profiles have now been completed and are ready for analysis.

### Drowned Forest Studies

Fieldwork on the study of drowned forests off the coasts of New England and the Maritime Provinces, which the Society has been enabled to carry out through the support of the Carnegie Institution of Washington, was concluded during the 1932 season by Professor Charles J. Lyon and assistants under the direction of Professor J. W. Goldthwait. Sample sections of trees were cut in five drowned forests selected from some fifteen examined, and a large number of graphs of average yearly growth were plotted. These graphs are now being analyzed and compared in the hope that correspondences in them may be found of sufficient length and consistency actually to establish parallelism and thus furnish a means of tracing the chronology of the submergence.

### Colorado Delta Studies

During the past year the fieldwork on the study of the Colorado Delta which Mr. Godfrey Sykes has been carrying on since 1929 under a coöperative arrangement between the Society and the Carnegie Institution of Washington was devoted principally to tracing recent flood limits and to noting and recording the location of such sloughs and abandoned channels as seem to give promise of developing into major waterways as the detrital invasion of the delta continues. In addition to the fieldwork good progress was made on the classification of silt, sand, and soil from critical localities and also in preparing for publication historical and narrative material on the delta.

### Expeditions

In addition to active association with three expeditions during the past year the Society has had the opportunity, through articles in the *Geographical Review*, to publish the results of several other expeditions of major importance.

The Society is participating in the support of the Yale North India Expedition, which is in the field under the leadership of Dr. Hellmut de Terra. This expedition has mapped about 4000 square miles on the scale of one-half inch to the mile in the eastern Karakoram and northwest Himalaya, has carried out geological and physiographic studies with a view to determining the structure and origin of the world's

highest mountain range, and has made large biological collections, including a collection of high-altitude fresh-water animals (mostly collected above 15,000 feet), and paleontological collections. At the beginning of October the expedition was to return to Srinagar for work in the Kashmir Valley and was to complete its work during December and January on the southern flank of the Pir Pangal Range.

The Society lent instruments to and assisted in plans for the continuation, during the summer, of the ground and aerial survey work in Labrador which Dr. Alexander Forbes has been carrying on for the past two seasons. This season the work was in charge of Mr. Charles Hubbard. A collection of the aerial photographs taken has been presented to the Society, and Mr. Hubbard is now working on the report.

The Society furnished maps to and assisted in the plans of Mr. Desmond Holdridge who for several months during 1932 led an ethnological and geographical expedition for the Brooklyn Museum in the unexplored section of northern Brazil between the Rio Branco and the Serra Parima. The surveys made by this expedition and a report on its geographical work will be published in the *Geographical Review*.

During the year there have appeared in the *Geographical Review* articles on the results of the Shippee-Johnson Peruvian Expedition of 1931, the Grenfell-Forbes Labrador Expedition of 1931, the *Graf Zeppelin* Aeroarctic Expedition of 1931, Norwegian Explorations in the Antarctic in 1930 and 1931, the archeological explorations of the Smithsonian Institution on St. Lawrence Island in 1928–1930, a study of the glaciers of Prince William Sound in 1931, explorations of the Sierra Nevada de Cocuy (Colombia) and along the eastern border of the Andes in western Venezuela, Miss Louise A. Boyd's expedition to East Greenland in 1931, explorations in the Tarim Basin in 1930, and explorations on the Chinese-Tibetan border in 1926.

## Department of Technical Training

Instruction was given to six students during the year, and the Society's diploma was granted to Mr. Walter A. Wood in recognition of his completion of the full course in mathematical geography. More than one hundred requests for technical information and advice were answered, and instruments were lent to four expeditions.

Several new instruments were acquired, including a sextant, a Brunton compass, and a sling psychrometer. Through the generosity of Miss Louise A. Boyd the staff of the Department has had an opportunity to study and practice with a Wild phototheodolite belonging to her, and Mr. Lincoln Ellsworth has kindly lent his new Plath bubble sextant for inspection and practice.

Considerable progress has been made on the preparation of the map for which a large series of oblique aerial photographs were made by the Grenfell-Forbes Labrador Expedition of 1931. The ground survey computations have been completed and a report issued. A thorough analysis of the aerial photographs has been made, but the actual plotting of the map has been delayed until the completion of a photogoniometer that the Society is having specially constructed. The detail topographical map accompanying the account, in the October number of the *Geographical Review*, of Miss Louise A. Boyd's Greenland Expedition of 1931 was constructed at the Society by this method from ground photographs.

The initial program of air navigation map research on which the Society has been engaged for the past three years was concluded with the publication of an experimental map of the Cleveland-Pittsburgh area in the January, 1933, issue of the *Geographical Review*.

## Library

Additions to the library during the year comprised 630 books, 1354 pamphlets, 1110 volumes of periodicals, 3139 maps, and 38 atlases. The collection now numbers 97,525 volumes of books and periodicals, 16,185 pamphlets, 85,672 maps, and 1662 atlases. The collections, in all categories, have doubled in the past sixteen years.

Among the gifts to the library and map collections in 1932 are: "American Historical Prints" by I. N. Phelps Stokes and "The Geography of Claudius Ptolemy" translated by Dr. E. L. Stevenson, from the New York Public Library; "Christopher Columbus," presented by the City of Genoa; Wordsworth's "Guide through the District of the Lakes," Jenkin's "Guidebook to Germantown," and two anonymous volumes, "History of the Mutiny at Spithead" and "The Egyptian," presented by Mr. R. P. Bolton; 22 pamphlets in Russian, dealing chiefly with botanical studies in the Russian Arctic, presented by the author, A. I. Tolmatchev; 41 pamphlets from the American Meteorological Society; a collection of 329 maps including a set of maps prepared for the Inquiry and for the American Commission to Negotiate Peace, 1918–1919, presented by Mark Jefferson; and a collection of 1260 books and pamphlets presented by Dr. Bowman. Other additions to the map collection were: 296 sheets of surveys of the Tennessee River and its tributaries on indefinite loan from the U. S. Engineer Office at Chattanooga, 131 sheets of river survey in Texas from the Texas State Reclamation Department, and 196 sheets of the Netherlands waterworks survey received on exchange from the Library of Congress.

Over 6400 items—books, periodical articles, and maps—were entered in the research catalogue. This catalogue, which was initiated as an experiment in 1923, now contains some 55,000 entries arranged according to a classification especially designed for the serious student of geography. During the decade that has elapsed since it was begun it has rendered services of incalculable value to all who have had occasion to use the Society's collections for purposes of research.

The library continued during the year its coöperation in the preparation of the *Bibliographie Géographique*, the *Union List of Serials*, and the *List of Serial Publications of Foreign Governments*.

## Honors

At the annual meeting of the Society on January 22, 1932, the Cullum Geographical Medal was awarded to Mr. Bertram Thomas in recognition of his explorations in Arabia.

At the meeting of January 22, 1932, Field Marshall Lord Allenby of Megiddo and Felixstowe was elected an Honorary Member of the Society.

At the monthly meeting of February 23, 1932, Professor Harry C. Heaton was elected an Honorary Member of the Society.

## Gifts

Miss Louise A. Boyd has donated to the photographic collection of the Society her large collection of photographs taken on her expedition to East Greenland in 1931, and Dr. Alexander Forbes has presented 150 photographs from the work of the Grenfell-Forbes Labrador Expedition of 1931. Other gifts to the photographic collection include photographs of Lillehammer, Norway, from Mr. H. P. Ulich; photographs of the southern and southwestern United States from Mlle. M. A. Lefevre; and photographs of the Antarctic from Rear Admiral Richard E. Byrd.

Mrs. Sidney Bradford has presented to the Society a selection from her late husband's collection of books, notebooks, and letters belonging to his great-grandfather, Captain Edmund Fanning, which will be known as the Sidney Bradford Bequest.

## Representation at Scientific Meetings

Members of the staff of the Society attended the annual meeting of the Association of American Geographers at Washington, December 28 to 30. A full report of the meeting will be published in the April number of the *Geographical Review*.

The Society was also represented at the annual meetings of the National Research Council, the Social Science Research Council, the National Academy of Sciences, and

a number of other organizations in whose work the Society is participating. Mention should also be made of the Society's representation on the policy committees of the National Research Council, the American Philosophical Society, and the Geological Society of America, the two last-named now having greatly enlarged opportunities through the generous bequests of the late Dr. R. A. F. Penrose. A representative is also serving on the Commission on the Social Sciences in the Schools, a Committee on Conservation of the National Academy of Sciences, and a number of other national committees.

### Lecture Program

During the past year the speakers and titles on the Society's lecture program were as follows: Mr. Bertram Thomas, "Crossing the Rub' al-Khali"; Dr. Alexander Forbes, "An Aerial Exploration of Northern Labrador"; Dr. James Mackintosh Bell, "The Great Lakes of the Far Canadian Northwest"; Sir Hubert Wilkins, "By Submarine to the Arctic"; Captain Robert A. Bartlett, "Voyaging to Greenland"; Mr. John A. Haeseler, "Berber Tribes of Northern Africa."

### Report of the Treasurer for 1932

The Council has received a report from the Treasurer giving a summary of the income and expenses of the Society, and the accounts of the Society have been audited by certified accountants whose report is on file at the office of the Society.

Philip W. Henry, *Chairman*

## REPORT OF THE SPECIAL COMMITTEE

New York, January 26, 1933

The committee appointed at the meeting of the Council held on December 15, 1932, to nominate officers for the vacancies to occur in the Council in January, 1933, beg to nominate the following named gentlemen for the offices designated and move that the same be approved and presented to the Society for election at its meeting to be held on January 26, 1933.

| | | *Terms to expire in* |
|---|---|---|
| *President* | John H. Finley | January, 1934 |
| *Vice-President* | Roland L. Redmond | January, 1936 |
| *Foreign Corresponding Secretary* | Frederic C. Walcott | January, 1936 |
| *Treasurer* | Henry Parish | January, 1934 |
| *Councilors* | Frederick Hellmann<br>Arthur Curtiss James<br>H. Stuart Hotchkiss<br>Oliver B. James<br>Frank L. Polk | January, 1936 |

John Greenough
F. Trubee Davison } *Committee*
Madison Grant

# GEOGRAPHICAL RECORD

## NORTH AMERICA

**The Vote by Counties in the Presidential Election of 1932.** On the accompanying map the areas comprising the counties carried by Hoover in the election of 1932 are shown in black. All the remaining counties were carried by Roosevelt with the exception of San Miguel County, N. Mex., where each candidate received 5364 votes.

FIG. 1—United States, vote by counties in the Presidential election of 1932. Scale 1:40,000,000, or about 600 miles to the inch.

This map may be compared with the map of the election of 1928 and the composite maps for the period 1876–1928 published in the *Geographical Review* last year (Vol. 22, 1932, pp. 360 and 668–669) as well as with the election maps in C. O. Paullin: Atlas of the Historical Geography of the United States (Carnegie Institution of Washington and American Geographical Society, New York, 1932).

The accompanying map gives no clue, of course, to the relative strength of the two parties in different states as measured by the popular vote. Owing to the way in which the large cities voted, Massachusetts, New Jersey, and New York, which seem like Republican strongholds on the map, were actually carried by Roosevelt. Pennsylvania, where there was much more Roosevelt territory than in New York, was carried by Hoover. The other states carried by Hoover were Maine, New Hampshire, Vermont, and Connecticut.

In the election of 1928 the only extensive unbroken Democratic area comprised the coastal plain and lower Mississippi Valley and reached from the northern edge of South Carolina into eastern Texas. A broad Republican "promontory" pushed south into this Democratic "sea" as far as the middle of Alabama. Even within the Solid South there were a number of Republican islands. Outside of the Solid South

there were only a few Democratic "lakes"—to pursue the analogy consistently—scattered over the country.

In the election of 1932 all the Republican islands in the Solid South vanished. Nothing remained of the Republican promontory of the Appalachians but a small archipelago in Kentucky, eastern Tennessee, and western North Carolina. From Pennsylvania to the Pacific the vast Republican continent of 1928 had given way to an equally immense Democratic ocean, dotted here and there with Republican islands. Within the Republican mainland of the northeast Democratic lakes that had existed in 1928 were enlarged and new Democratic lakes had appeared.

The last Democratic victory before 1932 was that of 1916. The pattern of that year was somewhat similar to 1932 but had two notable differences. In 1916 a wide Republican tract fringed with Republican islands extended westward and southwestward from Lake Huron into Missouri, Kansas, Nebraska, and the Dakotas. The margin of the Pacific coast was also mainly Republican, and the Appalachian islands of Republicanism were much more extensive than in 1932. The Democratic sweep of 1932 in the Middle and Far West may be ascribed mainly to the severity of agricultural depression in those parts of the country.

## SOUTH AMERICA

**Minerals and Water Power in Brazil.** The French geologist Henri Gorceix once said of the state of Minas Geraes: "C'est une poitrine de fer avec un coeur d'or." The heart of gold has played its part, but the breast of iron remains for the future. A recent paper by E. L. da Fonseca Costa (Richesses minérales et houille blanche au Brésil, *Ann. de Géogr.*, Vol. 41, 1932, pp. 618–630) presents the most recent information on this and other resources of Brazil.

Of all the known iron reserves of the world, 23 per cent are concentrated on the southern and eastern flanks of the Serra do Espinhaço in the central part of Minas Geraes, Brazil. Not only is this the largest known reserve, but also it is composed of the purest ore (68 per cent), with only a very small proportion of phosphorus (less than .02 per cent). It lies at or near the surface where it can be mined with a minimum of cost. Near Itabira, for instance, an enormous mass of iron ore forms a conspicuous mountain, probably all of which can be removed by the steam shovel.

In the same general area a wealth of other minerals is also present. Manganese of very good quality has already been mined, and the distribution of very large reserves of this mineral is known. There are also important occurrences of zirconium, chromium, molybdenum, nickel, tungsten, and beryl.

The coal resources of Brazil, however, are quite inadequate. Coal is found in the south, but the seams are thin and contain much clay. It could be put through a process for the removal of the impurities and made into good metallurgical coke; but the cost, together with the distance that separates it from the ore bodies, would probably render the utilization of the Brazilian coal impossible for other than local purposes.

Lacking coal, the presence in southeastern and southern Brazil of an abundant water-power reserve becomes all the more important. While there is a considerable seasonal variation in the rainfall, and while there are no natural lakes to regularize the flow of water in the streams, there is nevertheless an abundant run-off even during the season of low water, and the steep gradients of most of the streams in their descent from the elevated plateaus of this part of the continent provide a number of fine potential water-power sites. In southeastern Brazil considerable potential horse power exists along the short streams flowing eastward from the Serra do Espinhaço to the Atlantic. The Jequitinhonha and the Doce are the most important, especially the latter, which will probably furnish the outlet for the iron ore when this great wealth is utilized on a significant scale.

The southern margin of the Brazilian plateau between Rio de Janeiro and São Paulo has much potential power, of particular importance because of its location near these great urban markets (see A. W. K. Billings; Water Power in Brazil, *Engineering Journ.*, Vol. 13, 1930, pp. 493–503). Although the streams are short, the heavy rainfall and the steep drop to the coast afford many large power sites. This part of Brazil is said to be one of the areas of the world best endowed in this respect.

The Paraná River, too, can support a large hydro-electric development. The course of the river is youthful and is interrupted at numerous places by falls where it crosses the outcrops of the resistant diabase (see "Map of the Surface Configuration of a Part of Southeastern Brazil," Fig. 3, in P. E. James: The Coffee Lands of Southeastern Brazil, *Geogr. Rev.*, Vol. 22, 1932, pp. 225–244). Along the southern border of Brazil, where Brazil, Argentina, and Paraguay come together, the Paraná and its tributary the Iguassú pour over the edge of the diabase in spectacular falls, the Guayra Falls on the main stream, and the Iguassú Falls on the tributary. The volume of water in the Paraná, even during the dry cool season, is very great, about double the volume in the Niagara River. At this one fall alone there is a potential horse power at low water of 10,800,000, which rises to 60,000,000 during the rainy season. Only the remoteness of the falls, and perhaps the possibilities of international complications along the national boundaries, have postponed their development.

The first power plant in Brazil was built in Juiz de Fora, southern Minas Geraes, in the year 1889. At present there are some 467 plants. Every little village is furnished with light exclusively by electricity, however primitive the community may be in other respects. The greater part of the electric power is used for lighting and, in the larger towns, for street cars. However, in Rio de Janeiro and especially São Paulo city, a considerable market for power exists in the industries. The largest hydro-electric plant in South America at present is the one at Cubatão, near Santos, which supplies São Paulo and the neighboring communities. This plant has a maximum of 166,000 horse power installed, although it is capable of being expanded to some 750,000 horse power. A reservoir has been built on the crest of the escarpment known as the Serra do Mar. In spite of its headwater position, this reservoir can be filled in part by the enormous rainfall (over 3000 mm.) and in part by the pumping of water from the Tieté River only a short distance inland and only a few meters lower than the crest of the Serra. This work forms a part of a system for flood control on the rivers that flow by São Paulo city, including the reclamation of the Tieté Valley. From the reservoir to the power plant at the base of the Serra there is a drop of 725 meters. This and other similar plants mark the beginnings of a very considerable hydro-electric development.

PRESTON E. JAMES

**Town-Planning for Nictheroy.** In conjunction with the article on Rio de Janeiro and São Paulo (see pp. 271–298) reference may be made to an ambitious scheme for the development of Nictheroy described in the March and May, 1932, numbers of *La Vie Urbaine* (Attilio Corrèa Lima: Avant-projet d'aménagement et extension de la Ville de "Niteroi," Capitale de l'État de Rio-de-Janeiro). It is illustrated with a wealth of maps including an aerial mosaic, but unfortunately the reproductions for the most part lack clarity.

Nictheroy, vis-à-vis of Rio, occupies a site commanding the eastern portal of Guanabara Bay that might be described as a mirror image of that of its great neighbor. Nictheroy serves in part as a residential suburb for Rio, and it has a not inconsiderable industry. The growth of the city has been rapid in recent years—from 86,000 in 1920 to an estimated population of 130,000 in 1928. A great impulse to further progress would be given by direct and unbroken communication with Rio. Present connection is made by ferryboats, which in the "rush-hours" make the 20-minute crossing every quarter of an hour and carry an estimated number of 33,000

persons daily. The rival merits of tunnel and bridge are discussed, and a project for a bridge is described at some length. It would be a suspension bridge with two towers on the model of the George Washington Memorial Bridge (1931) over the Hudson at New York. It would extend from Calabouço Point at Rio to Gragoatà Point at Nictheroy and would be 8860 feet long with a central span of 3600 feet, as compared with 4760 feet and 3500 feet respectively for the New York bridge.

**The Chipayas of Bolivia.** In a bleak outlying region of the Bolivian desert, shunned by neighbors and far from the paths of strangers, a handful of people have maintained, through century after century, the manners and customs of an ancient civilization. The Chipayas, presenting this ethnographical riddle, are described by A. A. Guffanti (Fra gli Indios Chipayas della Bolivia, *Le Vie d'Italia e dell'America Latina*, Vol. 33, 1932, pp. 1019–1026). Their language has nothing in common with any other of the South American continent. They have not intermarried with their conquerors and neighbors the Aymará and have withstood all modifying influences.

The dwellings of the Chipayas are beside the Rio Llauca, some eighteen miles north of the Salar de Coipasa. Here the effects of the low temperatures of an altitude of 12,000 feet are accentuated by the strong afternoon wind which sweeps uninterrupted across the plain. The soil is salty and sterile; vegetation is scarce. There are few places on the earth's surface so uninviting to human occupation.

Though doubtless their ancestors lived by hunting and fishing, these survivors have turned to flock tending and to irrigation for life's necessities. Their houses are round, with the single door always turned toward the east. The circular form of these mud adobe walls offers less resistance to the cold wind; the position of the door obtains all the warmth possible from the morning sun.

To Alfred Métraux we are indebted for interesting data on the Chipayas, obtained on a recent expedition to their region (Chipayaindianerna: En folkspillra från en förgången andinsk kultur, *Ymer*, Vol. 52, 1932, pp. 233–271). He describes the Chipaya face as thin and angular, with the cheek bone not so pronounced as with other tribes of the altiplano. The Mongolian crease, so common in the countenance of Quechua and Aymará, is completely unknown here. The language lacks the gutturals of the Quechua and Aymará; its sounds are quite distinct and far more melodious. The Chipayas worship the volcanoes Sabaya and Sajama, as well as celestial bodies. Their dead are piled within *chullpas* of rectangular form and covered with fabrics, there to be conserved by the coldness and dryness of the climate.

The numbers of the Chipayas have fallen to less than 400, representing some 80 families. The Aymará scorn them, and even among their own clans there is continual discord. In truth the Chipaya has no friend, wishes no friend; years of oppression have developed within him a marked inferiority complex. Other Bolivian Indians get far more out of life, and so could the Chipaya; but his torpid mentality and lack of imagination make him stubborn to all progress.

W. E. RUDOLPH

## AFRICA

**A New Map of French North Africa.** In the January, 1933, number of the *Annales de Géographie* Emmanuel de Martonne introduces a new sheet of the "Atlas général Vidal-Lablache, historique et géographique," as the first general atlas map to depict French North Africa as the real geographical unit that it is, "profoundly different from the rest of the African continent and sealed with the stamp of France." The map, on the scale of 1:5,000,000 is a work of art. Professor de Martonne especially calls attention to the hachuring (in brown) as a good example of the merits of this method of showing relief. The skillful execution does indeed produce an exquisitely plastic effect. For instance, one notes the topographic contrasts between the Moroccan Atlas where the greatest intensity of relief is displayed and the chains

of Algiers and Tunisia, "montagnettes" in comparison; and again the precise configuration of the great eastern and western ergs and the orientation of the dune chains. The abrupt southern wall of the Jebel Aurès fronting on the desert is well shown, though without hypsometric tints the depression of the shotts is not graphically realized.

The picture of relief is completed by three insets in color—mineral wealth and rainfall on a scale of 1:20,000,000 and vegetation and land utilization on the scale of 1:12,000,000. They emphasize the distinction between the folded mountains and the rigid platform of the African plateaus. How illuminating, for instance, is the coincidence between the diminished relief on the Algerian-Moroccan boundary, where the plateau almost approaches the Mediterranean, and the northward advance of the 200 millimeter (7.8 inches) isohyet. Even today juncture between Morocco, whose isolation defied Roman penetration, and Algeria is difficult.

While human distributions are not shown, Professor de Martonne points out that the distribution of names is some clue to the density and nature of the occupation of the land.

**The "Suqs" of Morocco.** Official statistics class 13 per cent of the native population of Morocco as urban, dwelling in 33 towns (Jean Célérier: Le Maroc, Paris, 1931). Only three of these towns—Casablanca, Marrakesh, and Fez—have more than 100,000 inhabitants, and of these Casablanca has a large (one-third) European population. Only six other towns have more than 15,000 native inhabitants. The functions of urban life are, however, supplied in part by the *suqs*, or fairs, that weekly for a few hours introduce a "picturesque activity into the vast immobility of the *bled*." The importance of this institution is brought out in a map showing the distribution of suqs and the towns "of any size" (W. Fogg: The Suq: A Study in the Human Geography of Morocco, *Geography*, Vol. 17, 1932, pp. 257–267).

Every tribe and subdivision of a tribe has its suq: some of them of local interest only; others, especially those in the border zones between mountain and plain, attracting thousands from near and far. The general position of a suq is determined by custom and convenience, the site by the available water supply and the existence of suitable ground for a congregation of men and animals. In many cases the site coincides with that of the tomb of a saint. The larger suqs are laid out on a definite plan. In the heart are the tents of the authorities who represent administration, justice, and police. Around this nucleus are the tents of the chief traders, divided into three sections, foreign goods, homemade goods, and general groceries respectively. The tents are aligned in streets and occupy an assigned place. The traders in these commodities go from suq to suq on weekly or longer journeys. An outer circle in the open is occupied by miscellaneous traders and artisans, again in regular order similar to that of the towns. Mr. Fogg's diagrammatic plan shows the following arrangement: olive oil and soft soap, fruit, charcoal, bread, butchers, livestock, blacksmiths, grain merchants, pottery, barbers, shoe-menders, and lastly the entertainers.

As M. Célérier says, the suq "is a capital fact in the native life, not only from the economic, but from the social and political points of view," and the French have made good use of the opportunities offered for pacification and control. Inevitably modifications are in progress. Mr. Fogg notes the erection of warehouses, a hotel, a railway station, and European dwellings on the site of one of the larger suqs; and there are similar developments elsewhere, marking an evolution towards the European type of market town.

**The Seasons in Senegal.** The simple conception of the year divided into a rainy season and a dry season gives a very inadequate picture of the climate of Senegal. True, the most clearly marked periods are that with abundant rain (July, August,

September, and October) and that without rain (February, March, and April), the dry season proper, sometimes though incorrectly called the cool season, for under the east wind it is distinctly hot. Between, however, are transition periods. Preceding the season of rains is a period that might appropriately be called spring (May and June). Following is the *heug*, the season of little rains (November, December, and January). It is the coolest time of the year, but its length and characteristics vary greatly. Variation, both seasonally and regionally, is a feature of the rainfall of Senegal, as M. R. Rousseau shows in "Les Pluies au Sénégal de 1887 à 1927 (*Bull. Comité d'Études Hist. et Sci. de l'Afrique Occidentale Française*, Vol. 14, 1931, pp. 157–182). The country lies in an interesting transition zone, the rainfall ranging from less than 10 inches on the north to more than 55 inches on the south, over a breadth of less than 300 miles. Using records of 24 stations with Saint Louis, Dakar, and Tivaouane serving as "base stations" for correlation and interpretation, M. Rousseau presents a map of the annual rainfall of the colony on a scale of 1:2,000,000.

**Some Recent Journeys in the French Sahara.** "In the western Sahara we can still travel 800 km. in a straight line without cutting the track of any known itinerary" says Captain Augiéras, who himself made history by the first crossing from Algiers to Dakar (1920–1921). Some of the remaining white space was filled in by the Augiéras-Draper Expedition of 1927–1928, a report of which has recently appeared under the auspices of the Geographical Society of Paris (D'Algérie au Sénégal: Mission Augiéras-Draper 1927–1928, Paris, 1931). The expedition traveled by the established motor route from Algiers via In Salah to Tamanrasset, where exploration started. A choice of new routes lay before them. They could go southeastward to Lake Chad across the Ténéré or southwest towards Senegal. The latter route was chosen as presenting the "greatest unknown." The Tanezruft, the waterless desert, was entered at the abandoned oasis of Silet (compare the account by T. F. Chipp: The Vegetation of the Central Sahara, *Geogr. Journ.*, Vol. 76, 1930, pp. 126–137), and the expedition came out at Bourem on the Niger. A route map was constructed on a scale of 1:500,000 tied into eleven astronomically determined points. At Bourem the expedition divided. Mr. W. P. Draper and Lieutenant Eugène Gierzynski with a small convoy—lightness and swiftness are the chief desiderata in such exploration—proceeded north by the Taodeni salt route to Araouane, whence they traversed a completely unknown and waterless stretch of 500 kilometers to Oulata (map, 1:1,000,000). The remainder of the party went by boat up the Niger to Koulikoro, 1200 kilometers. While there was little new to be recorded on the river journey, many interesting details are noted, for instance the live Saharan dune become an island in the Niger! (p. 82).

The narrative of the expedition (Augiéras and Draper) and a report on the topography and geology (Vladimir Besnard) and plants and animals (Théodore Monod) are given in diary form. Captain Augiéras also describes the construction of the map, Lieutenant Gierzynski gives the meteorological observations, and M. Monod reports on one of the most interesting discoveries of the expedition, a fossil man, the first so far as known to be found in the Sahara. Marcellin Boule, who has examined the skeleton, describes it as having Bushman-Hottentot affinities. M. Monod also reports for Mr. Draper on the archeological collections and on the anthropometrical measurements of Tuaregs made in Tamanrasset. There are 36 plates of rotogravure illustrations, small but clear and covering all phases of the journey.

With the work of "linear" exploration in the Sahara so largely accomplished there is need for a stocktaking of regional knowledge, says M. Monod in his introduction to a monograph on the Adrar Ahnet. This region, between In Salah and In Ziza, is the western extremity of the northern sector of the "tassilian girdle" (*tasilé* is the Ahaggar term for this type of sandstone plateau) that surrounds the Ahaggar massif. History of exploration and the archeology are described in one volume (Théodore

Monod: L'Adrar Ahnet, *Trav. et Mémoires de l'Inst. d'Ethnol.*, Vol. 19, Paris, 1932), with a map, 1:550,000, in three sheets of the area between latitude 23° and 26° N. and longitude 1° and 4° E. A physical study (geology, in collaboration with Jacques Bourcart, who accompanied the Olufsen expedition of 1922–1923) is appearing concurrently in the *Revue de Géographie Physique et de Géologie Dynamique.* Reference may be made (*ibid.*, Vol. 4, 1931, pp. 223–262) here to the cross sections illustrating the cuesta structure discussed in this number of the *Geographical Review* by Professor Gautier (pp. 249–251).

The sand desert of the Ténèré was recently crossed by H. R. H. Prince Sixte of Bourbon (Great Routes of the Sahara, Past and Future, *Geogr. Journ.*, Vol. 81, 1933, pp. 97–107). It "stretches between the rocky massifs of Ahaggar and Air and the great cliff which, forming to some extent the frontier of the Tibesti, runs from Bilma to Tripoli. In the whole of this immensity there is but one really inhabited spot, Bilma . . . At Bilma it was only possible to find one single person who had ever been to Tibesti . . . Our motor cars had succeeded in reaching the military post of Sherda . . . we then continued by car in an easterly direction, and the whole time following unknown routes, as far as Borku."

## ASIA

**Land Tenure and Oil Concessions in 'Iraq.** The Special Report of the Mandatory Power on the "Progress of 'Iraq during the Period 1920–1931" (*Colonial No. 58*, 1931) is a unique document. "It is no less than an attempt of a guardian government to present to the whole world proof of its contention that its ward is now ready for full nationhood." (Luther H. Evans: The Emancipation of Iraq from the Mandates System, *Amer. Polit. Sci. Rev.*, Vol. 26, 1932, pp. 1024–1049). Among the elements of progress described are settlement of the frontiers (a Special Commission is still at work on the Syrian frontier), promotion of law and order, establishment of finances on a sound basis, settlement of nomadic tribes, advancement in public works, especially communications. And here one may parenthetically note the publication, by the government of 'Iraq, of "Maps of 'Iraq with Notes for Visitors," 1929, with its road maps on a scale of 1:1,000,000. "Agricultural conditions remain unchanged, except in so far as the introduction of oil pumps [for irrigation] has created new economic problems but much valuable research work has been done." It is, however, agriculture on which the welfare of the country must rest. "Subject to the overriding necessity of preserving public order and contentment and to the steady improvement of communications, the country's primary need is the reclamation of its derelict national estate and the regeneration of its agriculture," says Sir Ernest Dowson, who was appointed to inquire into the question of land tenure (An Inquiry into Land Tenure and Related Questions, Baghdad and London, [1932?]). Among the results of his inquiry is a map on the scale of 1:1,000,000 showing various types of land. It is estimated that 80 per cent of the country is unproductive. Of the productive portion only a fraction is cultivated in any given year. The northern part is dependent primarily on rainfall for cultivation; it amounts to 9 per cent of the country and supports a rural population of roughly 19 to the square kilometer; the southern part, 11 per cent, is dependent on irrigation and supports a rural population of about 35 to the square kilometer.

Comparison with Egypt is naturally invited. It is pointed out that in the last fifty years Egypt has more than doubled in population, has added 50 per cent to its cropped area, quadrupled in trade and budget, and largely absorbed the original external debt. Egypt has enjoyed advantage over 'Iraq in geographical position, but 'Iraq has a larger and more diverse cultivable area and petroliferous deposits that provide opportune financial aid.

If not the earliest, Mesopotamia was the best-known source of mineral fuel. Euro-

pean interest in its oil resources dates back some sixty years. The present status and the events leading up to it are briefly outlined by Frederick G. Clapp in "Oil Concessions in the Middle East" (*Mining and Metallurgy*, Vol. 14, 1933, pp. 89–92). In 1931 the existing oil concession was revised giving the concessionaire (Iraq Petroleum Co.) exclusive exploitation rights over all the country east of the Tigris with the exception of the Transferred Territories, ceded by Persia in 1913, rights over which remained with the Anglo-Persian Oil Company. The concessionaire undertook to complete a pipe line to the Mediterranean before the end of 1935, paying to the 'Iraqi government £400,000 (gold) a year until the beginning of regular export, when payment will be on a royalty basis. The pipe line is to run from the Kirkuk field, on which successful drilling is reported, southwest to the Euphrates, and thence one branch will go to Haifa, another to Tripoli. In 1932 the 'Iraqi government granted exploitation rights over the entire west side of the Tigris to a new oil corporation.

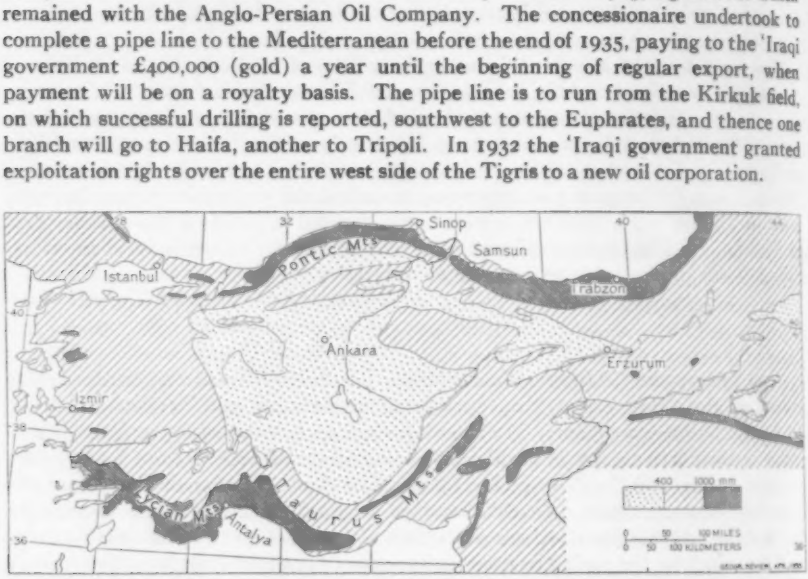


FIG. 1—Rainfall of Turkey, after Reichel. The original map in color (1:3,700,000) also shows the 600-, 800-, 1500-, and 2000-millimeter isohyets. The official Turkish spelling of town names is followed. Scale approximately 1:14,500,000.

**The Rainfall of Turkey.** The Turkish Meteorological Institute has been conducting rainfall observations at more than 100 stations since 1926. For many of these and for about twenty additional stations records are also available covering longer periods. On the basis of these data E. Reichel has prepared a study of the rainfall of Turkey (Die Niederschlagsverhältnisse der Turkei, *Annalen der Hydrogr. und Marit. Meteorol.*, Vol. 60, 1932, pp. 353–362).

A colored map of the mean annual rainfall brings out clearly the contrast between the dry interior and the rainy mountains, the Pontic and the Taurus and Lycian ranges, that fringe the Anatolian peninsula on the north and south. On the high ridges the annual precipitation probably exceeds 200 centimeters (79 inches), whereas the steppes of central Asia Minor receive less than 30 centimeters (11.8 inches). The Aegean borderlands and the highlands of Armenia are somewhat less arid than the saline plains south of Ankara (Angora).

Broadly speaking, winter is the rainiest season along the margins as well as in the western and southern parts of the interior. Early summer is the rainiest period in the northern and eastern interior. This summer rain, associated with the movement of cyclonic disturbances over the Black Sea and Russian plains, is of very limited quantity. Much of it falls during thunderstorms. As a region of summer rainfall, the heart of Asia Minor bears no analogy to central and eastern Europe. It should, rather, be regarded as "an island of subtropical continental climate shoved out into the Mediterranean climatic region."

The winter rains along the marginal mountains and over the southern third of the

interior may be attributed to the passing of "lows" along two pathways that skirt the edges of the peninsula, traversing the Black Sea and the eastern Mediterranean from west to east (see Ludwig Weickmann and others: Zum Klima der Turkei, Ergebnisse dreijähriger Beobachtungen, 1915–1918, Munich, [1922?], Part I, "Luftdruck und Winde im östlichen Mittelmeergebiet," p. 99). On the north coast the rain-bearing winds come from somewhat to the south of west. Consequently the southeastward-trending segment of the coast east of Sinop lies in a rain shadow, and a narrow strip along the shore is considerably drier here than farther east or west. On the Mediterranean side the excessive rainfall in Lycia and Pamphylia may be due to the presence of low pressures over the Aegean in midwinter. Toward these "lows" moisture-laden air is drawn. Forced to ascend over the mountain ridges it is cooled and the moisture precipitated. Reichel compares the excessive rainfall of this region to that of Venetia.

**Woodland and Pasture in Northern Turkey.** The broad lines of vegetation distribution in northern Turkey are readily apprehended from the rainfall map above. The sharp contrast between the abundant rainfall of the Pontic ranges and the arid interior is reflected in the contrast between the luxuriant Colchian woods (compare Ernest Nowack: Journeys in Northern Anatolia, *Geogr. Rev.*, Vol. 21, 1931, pp. 70–92) of the Black Sea slopes and the meager steppes about Ankara. John Frödin, who traveled in northern Turkey in 1930, made observations on the relations between the two zones (Quelques traits de la végétation et de l'habitat pastoral de la Turquie du Nord, *Geografiska Annaler*, Stockholm, Vol. 14, 1932, pp. 209–243). He asks if the steppe is original everywhere where it now dominates. Certainly true forests are rare on the plateau, but there are many small patches of woodland suggesting a once greater extension. About Gümüshane (south of Trabzon) the forest has been destroyed for the mines, with the exception of some poor remnants on the high crests, but twenty kilometers to the south a fine coniferous forest still exists. In the vicinity of Yozgad a beautiful pine forest (*Pinus pallasiana*) is found between altitudes of 1450 and 1640 meters, the sharply defined upper limit obviously artificial. In the environs of Yozgad and at some other points cultivation without irrigation implies that the climate is not hostile to a more luxuriant vegetation than that of the steppe.

Bound up with the vegetation is the pastoral habit. The Anatolian plateau is an ancient home of nomadism, but the bordering zones encourage seasonal migrations organized in relation to a permanent habitation. Dr. Frödin notes two types of such migration, one practiced by mountain dwellers who live on the floors and lower slopes of the larger valleys at altitudes of 700 to 1100 meters and send their flocks and herds for the summer to the higher valleys and slopes, some 1000 meters up and 8 to 15 kilometers away. Around the summer huts (yaïla) some agriculture may also be practiced. In the second instance are the dwellers in the low coast zone who take advantage of mountain pastures some 100 kilometers away, chiefly for sheep.

Dr. Frödin discusses Miss Carrier's definition of transhumance in "Grass and Water" (see *Geogr. Rev.*, Vol. 23, 1933, pp. 155–156). He would limit it to the Mediterranean type of double migrations from pasture to pasture without stabulation, such as must be resorted to in more northerly climates.

**The Physiographic Regions of Arabia.** Although Arabia is still the least known of the larger land masses outside the Antarctic, much scattered information has been gathered about different parts of it, particularly since the World War. Several attempts have been made recently to systematize and coördinate the details recorded by explorers. Walter Lesch, for example, under the title "Arabien: Eine landeskundliche Skizze," gives a comprehensive survey of physical geography, climate, vegetation, animal life, religions, peoples, trade, and politics (*Mitt. Geogr. Gesell. in München*, Vol. 24, 1931, pp. 1–153). Other studies of the same nature have already

been noted in these columns (*Geogr. Rev.*, Vol. 14, 1924, p. 174; Vol. 19, 1929, pp. 510–511).

In a somewhat similar paper entitled "Übersicht über Aufbau und Oberflächengestaltung Arabiens" Hermann von Wissmann interprets the geological history of Arabia and divides the peninsula into physiographic regions (*Zeitschr. Gesell. für Erdkunde zu Berlin*, 1932, pp. 335–357). An excellent geological map in color (1:7,500,000) accompanies his paper, together with black-and-white maps on the same scale showing the relief and the boundaries of the physiographic divisions.

With the exception of Oman (the folded mountains of which are an offshoot of the Persian folds) Arabia as a whole is an uptilted block. The steep side of this block faces the Red Sea rift and the gentle back slope falls off gradually into a geosyncline traversing Mesopotamia, the Persian Gulf, and the eastern end of the Rub' al-Khali. The crystalline foundation of Arabia is exposed only in the higher, western part of the peninsula where the uplift has been most pronounced. To the east the ancient crystalline base is covered by sedimentary deposits.

The Arabian block has been subjected to secondary deformations. Along the coastal borderland of the Indian Ocean uplift has produced a belt of mountains and plateaus. The highlands of the Yemen and Asir form an extensive horst, capped in part by trap and much dislocated and dissected around the edges. Over the entire west-central part of the peninsula (Nejd and the Hejaz) a gentle doming of the earth's crust has permitted weathering and erosion to strip the sedimentary cover from the crystalline base. Consequently the area in which crystalline rocks are exposed extends much farther east here than it does to the south and north of the dome. The doming of the sedimentary strata is reflected in a series of concentric cuestas, scarps, and subsequent lowlands partly encircling the great crystalline "shield" (see *Geogr. Rev.*, Vol. 19, 1929, p. 511). In northern Arabia and the Syrian desert the sedimentary beds lie almost horizontal, forming wide plateaus of sandstone, limestone, and chalk. The Nefud sand desert is due to the disintegration of a part of the sandstone plateau, the remainder of which is preserved intact farther to the west. The Nefud is connected with the Rub' al-Khali by long strips of sand desert on the floors of lowlands formed by the erosion of sandstones between the cuestas. Relatively recent lava flows cover parts of the crystalline uplands of Hejaz and Asir and the sedimentary plateaus of Transjordania. These are the desolate tracts known as *harra*. It is significant that basins of interior drainage are scarce in Arabia. The Wadi Sirhan, northwest of the Nefud, forms such a basin and is probably a graben. Other basins may be disclosed in the as yet unexplored parts of the Rub' al-Khali. Their scarcity, however, would seem to indicate that the surface of Arabia as a whole has been little deformed by tectonic movements since the Pleistocene period, for under existing climatic conditions the rims of basins could not be cut through by streams.

**Explorations of Philby, Rutter, and Sadek Bey in Arabia.** A year after Bertram Thomas made his memorable traverse of the Rub' al-Khali, or great southern desert of Arabia (*Geogr. Rev.*, Vol. 22, 1932, pp. 333–335), H. St. J. Philby visited its northern and northwestern portions (see *Journ. Royal Central Asian Soc.*, Vol. 19, 1932, pp. 569–586, and *Geogr. Journ.*, Vol. 81, 1933, pp. 1–26).

After leaving Jabrin on January 21, 1932, Philby made his way at first generally southward for about 400 miles by a route roughly parallel to Thomas' north-bound route. Thence, after a false start and forced retreat of over 125 miles to water, he pushed due westward across 350 miles of terrible drought and desolation to Sulaiyil, a village lying among the hills of Jabal Tuwaiq, a highland area that overlooks the northwestern margin of the desert. On the entire journey of fifty-three days from Jabrin to Sulaiyil not a human being was met with. It seems that a rumor of the expedition had preceded it, and all the pasturing tribes of the south had packed

up and moved "far back to the shelter of the southern mountains." Philby's small party inspired fear because it was traveling under the auspices of the powerful Ibn Sa'ud. During the southward march a few scattered wells were encountered. One was no less than 171 feet deep, "a remarkable piece of work which is clearly not to be attributed to the modern Badawin of these parts." Philby's guides led him to what they believed to be the site of the ruined city of Wabar, about which many legends are current in the desert borderlands. The "ruins" turned out to be meteoric craters. It is questionable, however, whether this discovery wholly disposes of the possibility of an ancient town in this part of Arabia. Thomas located but did not visit the supposed ruins of Ubar (or Wabar) at a point 150 miles farther south.

Notable as were the journeys of Thomas and Philby in these southern sands, there still remains to the south and west of their routes a tract of unknown country as large as New England and the Middle Atlantic states put together. Philby observed that the Bedawin, when they "have occasion to pay unfriendly visits to their neighbours across the desert generally skirt round the edges of it, keeping sufficiently near the wells on its boundary to call at them if there should be need. Similarly, grazing or hunting parties on all sides of the desert penetrate some four or five days' journey into its depths in favourable seasons, living on camel's milk and returning to their water-bases when their camels require a drink." Apparently they seldom, if ever, actually cross the heart of the desert.

Another important journey carried out two years before that of Philby is recorded briefly in the *Geographical Journal* for October, 1932 (Vol. 80, pp. 325–331). Toward the end of 1929 Eldon Rutter visited Haïl, traveling thither from Damascus by a route not far from Alois Musil's track of 1915. Haïl, once the important capital of the dynasty of Ibn Rashid, which dominated much of inner Arabia before the recent rise of the house of Ibn Sa'ud, has shrunk to a mere village of less than 2000 souls.

An interesting contribution to the history of the exploration of Arabia is made by Mustafa Amer to the *Bulletin de la Société Royale de Géographie d'Égypte*, Vol. 18, 1932, pp. 29–45. In the winter of 1861 Mohamed Sadek Bey, an engineer and officer of the General Staff of the Egyptian army, traveled from Wijh on the Red Sea coast to Medina and thence to the port of Yembo. Sadek left a circumstantial account of his trip in a small book in Arabic published at Cairo, A. H. 1294 (A. D. 1877). Apparently only one copy of this book is now known. Sadek was "the first to explore and fully describe the route between Wijh and Medina; the first, with the help of instruments, to map this route; and the first, again, to make an exact plan of the 'Haram,' and to take photographs of the Holy City and of the Great Mosque." Amer gives a résumé of Sadek's observations and reproductions of his plan of the Haram and of some of the photographs. The discovery of Sadek's volume suggests the interesting possibility that other diaries or records of the travels of Egyptians in Arabia may come to light.

**A Daytime Census in Tokyo and the Center of Population in Hokkaido.** We have had censuses of "cities awake" in London and Boston (cf. Mark Jefferson: Distribution of the World's City Folks, *Geogr. Rev.*, Vol. 21, 1931, pp. 446–465). Now comes the report on a third daytime count of population in a million city—that taken in the midst of Tokyo, November 5, 1929. Of the 2,070,529 inhabitants estimated for Tokyo for 1930 the four central wards, an area of 845 acres, had that day 169,262, not counting "passengers on the streets (including those in vehicles as well as pedestrians) and visitors or clients in the house." Of this number 45,561 were "settled inhabitants," which leaves the students and employees who came in to study or work numbering 123,701. At the regular census of 1925, four years earlier, there were reported 68,298 nighttime inhabitants. Apparently the nighttime dwellers

in the four central wards diminished by 12,737 in the four years, just as the central city of London diminished from 13,709 in 1921 to 10,896 in 1931; but the rate of diminution is quite different, 281 a year in central London, 3189 a year in Tokyo. This astonishingly rapid falling off of the nighttime population of central Tokyo may be because the phenomenon is new there but old in London. London has in the 675-acre central city a daytime density of 644 an acre and a night density of only 20, while Tokyo drops from 200 by day to 81 by night.

The limitation of the count to the four central wards was a matter of economy. Its results are described by Shigeyoshi Kanaya in *Bulletin de l'Institut International de Statistique* (Vol. 25, No. 2, 1931). Among other papers in this volume presenting population statistics of Japan is one by Kumao Takaoka on the center of population of Hokkaido. We have been given to understand that Hokkaido's northerly position, making it unsuitable for rice growing, has prevented any good relief for the overpopulation of the south; but the numbers there are already more than two and a half million as compared with less than 60,000 in 1869. The annual increase has steadily risen under government sponsoring of immigration, amounting to an average of 77,000 for the years between 1916 and 1920. For the average of the five years 1920–1925 it fell back to 28,000. This is reflected by a retrogression of the center of population to the south-southwest again after a long steady advance in a direction 50 degrees east of north. In 1920 the center was about 30 miles southwest of the middle of Hokkaido's main quadrilateral. It would seem that, in default of new spread of immigration to the northeast, the biologic increase in the denser population of the southwest drew the center of population that way.

MARK JEFFERSON

## POLAR REGIONS

**The Norsemen's Farthest North in Greenland.** In his book "New Land" (1904, Vol. 2, pp. 310 ff.) Otto Sverdrup mentions a small island called St. Helena in the western part of Jones Sound (about latitude 76° N., longitude 90° W.), where he found many eider duck nests of a peculiar kind. They were built by human hands and were of the same construction as is in vogue at the present day in the northern part of Norway. He found this strange because the Eskimo are not in the habit of protecting birds in this fashion, and everything seemed to indicate that the Sverdrup expedition was the first civilized people to visit the spot. One member of the expedition, Gunnar Isachsen, has now, together with Fridtjov Isachsen, taken up the subject for further discussion in an article published in a recent number of the *Norsk Geografisk Tidsskrift* (Vol. 4, 1932, pp. 75–92). He supplements the information given by Sverdrup. From this it appears that they also found at Björneborg on the south coast of King Oscar Land, not far from the island of St. Helena, two cairns of an unusual construction for these regions. In 1875 Sir George Nares had found on Washington Irving Island in Kane Basin (latitude 79° 35′ N., longitude 73° W.) two similar cairns, apparently old and in a place that, so far as was known, had not been visited by white people in modern times. Since cairns of this kind, built by the Eskimo, have not been found elsewhere, it seems doubtful whether these could be of Eskimo origin.

Hitherto it has been generally assumed that the Norse colonists of medieval Greenland on their fishing expeditions along the west coast did not get farther than the island of Kingigtorsuak (latitude 72° 58′ N.), where the runic stone was found. It is curious to note that on the highest point of this island three cairns are to be found that apparently are of the same age as the runic inscription (1333). They doubtless were built by the Norse Greenlanders, although it is difficult to say for what purpose. It has been suggested that they were built to mark the northernmost point reached by the colonists. Mr. Isachsen raises the question whether the other cairns might not be of Norse origin as well as the eider duck nests. This seems to be within the

limits of possibility. The colonists might have penetrated so far north. But this is not a sufficient proof. Although it is not on record, whalers and fishermen might have visited these places prior to the two expeditions. There is no way of telling where they went who never returned home, as was the case with many a fishing ship in bygone days. Major Isachsen's theory, however, should not be disregarded.

H. HERMANNSSON

Completion of the Scientific Results of the Gauss Antarctic Expedition. With the recent appearance of Volume 20 the publication of the reports containing the scientific results of the German Antarctic Expedition of 1901–1903 on the *Gauss*, which was under the leadership of Erich von Drygalski, has been completed. That nearly twenty-seven years elapsed between the publication of the first volume in 1905 is in part due to the interruptions of the World War and its aftermath; but its explanation lies mainly in the monumental nature of the work. No other polar expedition has yielded so ample a harvest; among the reports of scientific voyages touching the Antarctic only those of the Dumont d'Urville and *Challenger* expeditions surpass it in number. The twenty volumes consist of more than 80 parts, many of them containing several monographs; there are two atlases besides. The total number of contributors was 105.

Although zoölogy is allotted the lion's share of space (Vols. 9–20), owing to its primarily taxonomic character and in order to do justice to the more than 4000 species that were collected, the fact that the leader of the expedition and the editor of its reports is a geographer has insured an adequate representation of the earth sciences and paved the way for the more synthetic treatment demanded by them. The outstanding contributions are in the fields of oceanography, meteorology, and glaciology. In the last-mentioned field Professor Drygalski has discussed the land and sea ice of the Antarctic ("Das Eis der Antarktis und der subantarktischen Meere," Vol. 1, Part 4, Berlin, 1921). This 300-page monograph, in which inland ice, shelf ice, pack ice, and their transitional forms are dealt with genetically, takes its place as a standard work beside the "Glaciology" of C. S. Wright and R. E. Priestley (scientific reports of the British Antarctic Expedition, 1910–1913, London, 1922) and A. B. Dobrowolski's "Historja naturalna lodu" (Natural History of Ice), Warsaw, 1923.

To meteorology are devoted Volumes 3 and 4 and an atlas. As most of these reports have already been appraised in these pages (reviews by Arctowski and Ward, *Bull. Amer. Geogr. Soc.*, Vol. 45, 1913, p. 697, and *Geogr. Rev.*, Vol. 6, 1918, pp. 523–524), it is necessary here only to remind the reader that they contain, not only a discussion of the meteorological observations of the expedition, but a masterly summary, based on the totality of results of international coöperation, of the meteorology and climate of the southern hemisphere south of the 30th parallel (by W. Meinardus and L. Mecking, Vol. 3, second half, Parts 1 and 2, and atlas consisting mainly of reconstructed *daily* weather maps from October 1, 1901, to April 1, 1904, for the zone between 30° and 70° S.). Here, again, an outstanding achievement is Meinardus' discussion of the air circulation in the Antarctic (Die Luftdruckverhältnisse und ihre Wandlungen südlich von 30° S. Br.: Ergebnisse und Probleme antarktischer Forschung, Vol. 3, second half, Part 2, pp. 133–307, Berlin, 1928), a topic to which G. C. Simpson had already made a notable contribution (scientific results of the British Antarctic Expedition, 1910–1913: Meteorology, Vol. 1, Calcutta, 1919, Chapters 6 and 7). An example of geographical prognostication, which forms a detail of a preliminary version of this discussion (Vol. 3, first half, pp. 319–323), may here be cited. From an analysis of the pressure distribution and the resultant wind directions at the Gauss station Meinardus had already in 1911 deduced that the then unknown coast of the Antarctic Continent west of the station (which lay in 90° E.)

trended W. by S. and E. by N. for a considerable distance and that the embayment thus defined between the Gauss station and Kemp Land (60° E.) represented a flat arc (and not a deep reëntrant, as often shown on maps derived from the physical map of the world in the *Challenger* reports, Vol. 1, First Part, Narrative). Both the coastal trend and the flatness of the embayment arc were confirmed to the letter by the 1930–1931 work of the *Norvegia* (*Geogr. Rev.*, Vol. 22, 1932, Pl. I) and Mawson expeditions (*Geogr. Journ.*, August, 1932, map).

Oceanography is represented in the series mainly by the major report by Professor von Drygalski (Vol. 7, Part 5), already noticed in these pages (*Geogr. Rev.*, Vol. 16, 1926, pp. 321–322 and Vol. 18, 1928, pp. 348–349), which culminates in a discussion of the influence of the Antarctic on world oceanic circulation. There are tidal reports (Vol. 7, Parts 5 and 6) and a report on bottom samples (Vol. 2, Part 6).

The other reports of geographical interest deal with the physical geography and geology of the Gauss station region and the sub-Antarctic islands visited (Vol. 2, Parts 1–5), with glacial débris (Vol. 2, Part 7, reviewed in *Bull. Amer. Geogr. Soc.*, Vol. 45, 1913, p. 697), with the vegetation of the sub-Antarctic islands (Vol. 8, Parts 1 and 3), and with the biological significance of the Antarctic (Vol. 10, Part 4). The most important maps published in the reports are: the Gaussberg and the inland ice margin in its vicinity, 1 : 15,000 (Vol. 1, Pl. 15); the shelf ice near the station, 1 : 250,000 (*ibid.*, Pl. 16); the track and soundings of the *Gauss* in Antarctic waters, 1 : 2,000,000 (*ibid.*, Pl. 17; text, Vol. 1, Part 2); submarine relief of the southwestern Indian Ocean, about 1 : 20,000,000 (Vol. 7, Pl. 5); and currents of the eastern Atlantic and southwestern Indian Oceans (*ibid.*, Pls. 6 and 7).

A small point concerning the bibliographical aspect of the work may here not inappropriately be mentioned. The title of the twenty volumes is "Deutsche Südpolar-Expedition, 1901–1903." The absence of such words as "Wissenschaftliche Ergebnisse" makes citation somewhat ambiguous and awkward. A like omission characterizes the reports of the scientific results of the British Antarctic Expedition of 1910–1913, whereas the editors of the *Challenger* reports evidently did not consider precise designation an inconsequential detail, nor do those responsible for the publication of the scientific results, now appearing, of the German Atlantic Expedition of 1925–1927 on the *Meteor*.

## WORLD AS A WHOLE AND LARGER PARTS

**Irrigation in the Caspian Lowlands.** Whether projected irrigation on a large scale in the lower Trans-Volga region will ameliorate the prevailing hot, dry climate is a question that has received much attention. Professor J. C. Timhoiroff, in an article entitled "Water Balance of the Caspian Sea and the Caspian Lowlands" (*Meteorol. Rev.*, No. 6–7, U. S. S. R., 1932; in Russian), denies any important ameliorating influence of extensive irrigation.

The relict seas of Caspian and Aral are responses to climatic factors of precipitation and saturation deficit of the atmosphere. The Caspian Sea was disconnected from the Black Sea at the end of the glacial epoch. Since that time the water level has fallen 26 meters below ocean level. Contrary to Baer's conclusion, Schokalsky, Berg, Wangenheim, and Kaminsky conclude that the lowering of the water level is due to climatic influence and not to diastrophism. Evidence of the climatic influence on Caspian Sea levels is seen in the comparative fluctuations of Caspian and Aral sea levels. Notwithstanding the fact that these seas lie near each other within the same climatic zone their fluctuations are in direct opposition. The explanation of this paradox is found in the following conditions. Hot and dry summers reduce the flow of the Volga River, which is the principal tributary of the Caspian Sea. The same conditions favor increased melting of glaciers that feed rivers tributary to the Aral Sea. Cool summers produce the opposite effect.

The water balance of the Caspian Sea is presented in the following estimates of annual loss and gain:

| Evaporation | Depth | Water Contributed | Per Cent | Depth |
|---|---|---|---|---|
| By inflow of rivers . . | 1040 mm. | VolgaRiver . . . . | 70 | 730 mm. |
| By evaporimeters . . | 1085 mm. | Conrah River . . . | 5 | 50 mm. |
| By thermal balance . | 977 mm. | Ural River . . . . . | 2 | 20 mm. |
| | | All rivers . . . . . | 81 | 840 mm. |
| Average . . . . . | 1034 mm. | Direct precipitation . | 19 | 200 mm. |
| | | | 100 | 1040 mm. |

Thus it appears that at present a state of equilibrium is being maintained. The fluctuations in water levels from year to year correspond to variations in inflow and evaporation.

The Volga lowlands, for which an extensive irrigation is projected, are semidesert. Only the Volga and Ural rivers cross the region; local drainages end in playas or "dry lakes." Annual precipitation varies between 160 and 300 millimeters. Evaporation from free water surfaces varies between 1200 and 1400 millimeters and reaches 1500 millimeters in the central part of the region. Mean evaporation from irrigated soil is 850 millimeters. While the absolute humidity of the Caspian lowlands is similar to that of Leningrad, the relative humidity is much lower. The striking difference of the climate is due to the great saturation deficit of the atmosphere. The Caspian lowlands are the hottest area of all Europe, with a closed July isotherm of 25° C. The cause of this aridity is to be found principally beyond the region, in the incursion of hot winds from the deserts of Central Asia. How then could irrigation ameliorate these arid conditions? Control of these *suhovei*, or dry hot winds, which often reach temperatures of 40° C., blow with hurricane force, and bring in a "dust fog," is impossible. The effects of any ameliorating measure by irrigation and windbreaks must be local. Irrigation of the Caspian lowlands will make possible the growth of crops suitable to the region, but no noticeable changes in climate are to be looked for. The Volga when impounded by dams will not change the *suhovei*, but by its dispersion over irrigated lands and losses by evaporation the inflow into the Caspian Sea will be correspondingly reduced. If the total flow is utilized for irrigation the level of the Caspian Sea will drop 0.7 meter annually. Falling sea levels will expose additional desert lands. Such are considerations involved in the projected large-scale irrigation of the Caspian lowlands.

W. C. Lowdermilk and N. Mirov

## HISTORICAL GEOGRAPHY

**The Tide in Ancient Science.** On the shores washed by the Mediterranean Sea the tidal phenomena are not at all impressive. The range of the tide here is but a foot or two at most places; and as a consequence of this small range, the regularity of the tide is frequently masked by the disturbing influences of wind and weather. Of little importance in the everyday affairs of the ancient Mediterranean peoples, the tide likewise received but little attention as a subject of study and speculation. It is therefore not surprising that the knowledge of tides in the ancient Mediterranean world, as it has come down to us, appears exceedingly fragmentary and abounds in fanciful explanations.

In a paper under the title "Les marées dans la science ancienne" (*Praktika de l'Académie d'Athènes*, Vol. 7, 1932, pp. 194–203), Professor Demetrius Eginitis reviews the knowledge regarding the tides that was current in the Mediterranean world during the five centuries from Plato to Pliny. By a critical reading of the texts of the ancient writers, he shows that certain ideas ascribed to some of these writers, notably Aristotle, are due to erroneous interpretations of later compilers. Eginitis goes even further and suggests that Aristotle envisaged the large range of the tide on the coasts of the Atlantic Ocean as resulting from the reflection of the tide wave from the coasts and thereby anticipated the modern theory of the tide as a stationary wave.

## GEOGRAPHICAL NEWS

**Sixteenth Session of the International Geological Congress.** The sixteenth session of the International Geological Congress will meet in Washington, D. C., from July 22 to 29 of this year. Before the Congress there will be excursions to various parts of the eastern United States, lasting from four to twelve days, and a transcontinental excursion eastward from San Francisco for those coming to the Congress from the west. Alternate days during the sessions of the Congress will be given to excursions to areas around Washington. After the sessions there will be two longer transcontinental excursions, each lasting thirty-one days, and two shorter excursions, one for the study of the glacial geology of the central states, the other for the study of the pre-Cambrian area, including the iron and copper deposits of the Lake Superior region.

Among the topics announced for special discussion are the following: measurement of geologic time by any method, geomorphogenic processes in arid regions and their resulting forms and products, fossil man and contemporary faunas, orogenesis, geology of petroleum, copper resources of the world.

Membership in the Congress is open to any one interested. For information address Mr. W. C. Mendenhall, General Secretary, U. S. Geological Survey, Washington, D. C.

## OBITUARY

**Henry Grier Bryant.** Mr. Henry G. Bryant died in Philadelphia on December 7, 1932, in his seventy-fourth year. For more than forty years he was associated with the Geographical Society of Philadelphia, serving as its president for many years. He was one of the original members of the Association of American Geographers and was president in 1913, on which occasion he delivered an address on "Government Agencies and Geography in the United States," a theme akin to his paper "The Record of the United States in Geography, 1889–1913" read before the Tenth International Geographical Congress (1913).

Mr. Bryant engaged widely in travel and exploration. He participated in the Peary Relief Expedition of 1892 under Professor Angelo Heilprin and commanded the Peary Auxiliary Expedition of 1894. He made three expeditions to Labrador—to the Grand Falls in 1891, along the coast to Nain in 1909, and up the Augustine River in 1912 (An Exploration in Southeastern Labrador, *Bull. Geogr. Soc. of Philadelphia*, Vol. 11, 1913, pp. 1–15). A particular phase of Mr. Bryant's Arctic interests was his drift cask experiment (see *Bull. Amer. Geogr. Soc.*, Vol. 38, 1906, pp. 105–107). Mr. Bryant was a member of the American Alpine Club, and his climbs ranged from Alaska to Java. A memorial to him appears in the January, 1933, number of the *Bulletin of the Geographical Society of Philadelphia*.

# GEOGRAPHICAL REVIEWS

## Russia and the Russian Environment

P. Camena d'Almeida. **États de la Baltique—Russie.** 355 pp. [Baltic States, pp. 1–33; Russia, pp. 34–342]; maps, diagrs., ills., bibliogrs., index. *Géographie Universelle*, Vol. 5. Librairie Armand Colin, Paris, 1932. 100 fr. 11½ x 7¾ inches.

Hans von Eckardt. **Russia.** Translated from the German by Catherine Alison Phillips. xxix, 711, and vii pp.; maps, diagrs., ills., index. Alfred A. Knopf, New York, 1932. $7.50. 9½ x 6½ inches.

Lancelot Lawton. **An Economic History of Soviet Russia.** Vol. 1, pp. ix and 308; Vol. 2, pp. viii and 309–629; index. Macmillan and Co., Limited, London, n. d. $6.50. 9 x 5¾ inches.

Since the work of Réclus no study of the geography of Russia so authoritative and exhaustive as that of Camena d'Almeida has appeared. The main emphasis is on climate, physical features, and biogeography, though other aspects are by no means neglected. The author's wide scholarship is evident throughout; he draws on researches past and present and enlivens his text with apt references to Russian literature. Particularly welcome are the accounts of the relief of northeastern Siberia based on Obruchev's work and of glaciation in the region south of the Trans-Alai, studied by the Russian-German expedition in 1928, each illustrated by a sketch map. References are made to recent earthquakes and to the recent destructive volcanic eruption in Kamchatka. Maps show the position of such new centers as Magnitogorsk and the Karagand mines; a geological sketch map of the Kusnetsk coal basin also appears. The route of the new "Turk-Sib" is shown, and this makes all the more surprising the total omission of any account of air routes or wireless stations, especially those designed to facilitate navigation on the northern coasts.

Many valuable climatic tables are given, and it is refreshing to find importance attached to an oft-forgotten aspect—the number of days free from cloud. For several places the number of days of rain and snow are stated. In discussing seasonal effects, reference is made to the holding of many fairs in winter because transport was then easier, though that of Nijni Novgorod was held in summer. Incidentally the effect of a good harvest on the number of weddings in October and November is mentioned.

On the question of progressive desiccation, especially in Russian Central Asia, little is said. In describing the evidence of former populations depending on irrigation at Anau, the author suggests that insecurity, wars, neglect, and nomad incursions are less problematic and more patent causes of decadence. This is borne out by the extreme slowness of revival in the irrigated regions of Turkestan after the disturbances that followed the year 1917, in spite of the much better scientific help now available. Professor d'Almeida considers that the Amu-Darya reached the Caspian up to the end of the sixteenth century, a view by no means generally accepted, in spite of his statement that it is no longer seriously contested.

A particularly good feature of the book is the description of regional land forms, the text being helped out by sketch maps and photographs, e.g. the striking photographs of Lake Issyk-kul and the Klimgob Valley (Pl. 58), of barchans and a *takyr* (Pl. 54), and of the Trans-Alai scenery (Pl. 59).

Taking the study as a whole, while each region is described in great detail and so vividly that innumerable sharp pictures are mentally photographed, the interplay of relations between the respective regions is not so well brought out. Russia in its separate parts, and especially the diverse regions of Asiatic Russia, could hardly be better treated; but the impression of Russia as a whole is blurred. The Caucasus and Transcaucasia, especially essential to the modern economic life of Russia, are dealt with in a separate volume. The general problems arising from the vast extent of the country and from the sharp seasonal changes almost everywhere obtaining, the distance of the center of government from the peripheries, the distance between sources of fuel supply and industrial centers, the lack of balance in population distribution are all factors that need more than regional treatment. A special difficulty of modern Russia—its need to expand yet farther into the more severe climatic régimes of the north and east in order to compensate for the loss of industrial Poland—is not touched on. The climatic disadvantages of Magnitogorsk are evidenced by the compulsory cessation of work owing to severe frost in January, 1933.

But all geographers are deeply indebted to the author for this profound and scholarly attempt to deal with so unwieldy a unit. It is a task demanding close and prolonged research, for the sources of information are scattered, are in a language difficult to acquire, and need much skill in selection. Professor d'Almeida has given us a carefully documented work, written in a clear and vivid style, and has made available to Western students the fruits of the researches of a great band of Russian explorers and geographers.

The greater part of Eckardt's weighty volume is devoted to historical outlines in which an attempt is made to trace the origins of the political institutions, spirit, civilization, and economic life of Russia. For the geographer the first section of Part VI, which deals with the people and their land in the present Union of Socialist Soviet Republics, is of particular interest. The author points out that over a third part of Russia in Europe "the bare livelihood that is all the inhabitants are able to gain is at the mercy of the hard law of climate, which has always absorbed the greater part of their strength." He considers that, though the individual seasons may each have their own charm, the climate is not propitious to human existence, since there must be a perpetual effort at protection either from cold and snow, from damp and mud, or from drought, heat, and dust. The severance of the western fringes—Poland, the Baltic States, and Bessarabia—has thrown Russia back towards the east, that is, towards regions of greater climatic severity. The shutting off from the Baltic Sea and the need to replace the highly industrialized Polish centers have led to migration of population towards the north and to the establishment of industrial centers in Asiatic Russia, where extremes of heat and cold are great and where water supply is often inadequate. Thus environmental conditions, quite apart from shortage of food and fuel due to the present régime, have become harsher. For the vast sweep of Russian agricultural masses "the Red Kremlin is still far away, the heavens are high above, and the forces of Nature remain inexorable." But not only has the new Soviet state developed towards the geographical east, but eastern and Asiatic elements of the population increasingly flock into European Russia and in ever greater numbers are absorbed into the Great Russian body corporate, with what effect on future generations time alone can show. The present already shows us the Caucasian Stalin ruling the Russians and spreading in the form of "liquidating the kulaks" the ancient Caucasian vendetta and feud between family and family.

There is a good, if brief, summary of the new economic and political divisions, and reference is made to the difficulty of balancing the new particularism of the national units, strengthened by encouragement to speak their own language and preserve their own culture, by efforts to tighten economic links. The state of flux still prevailing in Russia is evidenced by the fact that some of the political and eco-

nomic boundaries outlined have since been changed again. Also the confusing change of names goes merrily forward, and Nijni Novgorod is now re-christened "Gorky."

It is impossible to consider all the points that are raised in this book. It is the product of wide knowledge, is original and stimulating. It is illustrated with tables and diagrams and seven maps and numerous photographs well chosen to give pictures of contemporary Russia.

Lawton's book, which is undated, has two other serious defects; there is no map, nor is there any discussion of the natural environment on which economic history, however modified by temporary policies, must ultimately depend. In his first chapter the author lays down as the root cause of the economic situation at the time of the revolution the prolonged struggle between Russia and the East. This undoubtedly was an important factor, but a geographic factor is probably of even greater import; as is pointed out on page 215, records of famine occurrence in Russia go back for 900 years. These famines have always resulted from drought, most aggravated in those years when a light snowfall is followed by absence of spring rains. The meteorological conditions leading to these disastrous droughts occur at irregular intervals, so that years of famine may be followed by several years of good harvest. The tendency in the past was to accept the famines as unavoidable disasters. Today improved methods of communication and of irrigation hold out hopes of lessening the worst sufferings of humanity in occasional famine regions, but even with all the help of modern science such areas are economically handicapped. In certain districts of Russia few people have reached middle age without experiencing at least two periods of desperate hunger following bad harvest; the resultant lowering of physical vitality, especially when such prolonged inadequate feeding occurred in childhood and adolescence, is probably one factor in the much discussed passivity of the Russians.

The author, however, does not discuss these and other permanent economic disabilities of Russia. He concentrates on the policy of the Soviet government and its repercussions on the condition of the people from year to year, and from this point of view his work is indispensable to students of conditions in that country. It is a careful, well-documented, clearly expressed account of the varying problems that have arisen since the revolution began (for, as the author justly points out, it is still in progress) and of the expedients adopted as crisis after crisis has developed. Many illuminating glimpses of daily life are given, and Chapter 47 is a dramatic and poignant picture of the peasant faced by the drive to collectivization. Lawton states that the Five Year Plan cannot be considered as an instrument coördinating the whole economic life of the country since it concentrated on artificially stimulating heavy industry, which even today occupies only a negligible part of the population, to the detriment of agriculture. His summing up of the new Russian as the vanguard of a bourgeoisie new to Russia, though familiar in the rest of the world, may seem surprising but has more than an element of truth.

R. M. FLEMING

### MAPPING AND GLACIOLOGY BY THE ALAI-PAMIR EXPEDITION

RICHARD FINSTERWALDER. **Geodätische, topographische und glaziologische Ergebnisse.** Vol. 1, x and 218 pp.; text, diagrs., ills. Vol. 2, maps and diagrs. (Wissenschaftliche Ergebnisse der Alai-Pamir Expedition, Part I.) Dietrich Reimer (Ernst Vohsen), Berlin, 1932. RM. 78 for both vols.

The purpose of the Alai-Pamir Expedition was to conduct a fundamental study of the mountains of Northwestern Pamir, especially the little-known Seltan and Trans-Alai groups, recording geographical, geological, morphological, and glaciological data. The basis of this ambitious program was the production of accurate maps.

Ground photogrammetry controlled by an accurate triangulation was the survey method employed, and much of the book is devoted to a helpful discussion of the

methods used and their limits of accuracy. Dr. Richard Finsterwalder, already well known in the field of photogrammetry, has succeeded in demonstrating brilliantly the success of the method for rapid and accurate work on exploratory surveys of difficult country. One of the chief advantages of the method is that land forms may be drawn semi-automatically in stereoscopic plotting machines in the comfort of the office, thus eliminating the difficulties and inaccuracies inevitable in plane-table work where the topography controlled only by a series of points must be sketched in by eye in the field.

Even a brief review should not omit a word of praise for the thoroughness of the work or for the devotion of these men of iron, who toiled in the cold, naked heights of the Pamir to produce the extraordinary results presented in this book. So far as the reviewer knows, no other route maps of Asia compare with these. The glaciated mountains and the ice fields and glaciers are admirably recorded. The regional map is on the scale 1:200,000, the detail maps 1:50,000, and 1:12,500. A general map of Pamir and western Turkestan on the scale 1:2,200,000 is included.

The glaciological work was conducted by geodesists, not by geologists. Their studies are characterized by accurate measurements and by careful mapping. They have not found evidence of several glaciations, nor of former greater extent of glaciers, nor of ancient valley floors. They measured the rate of movement of the ice at many points and show that the rate increases from 1 to 3 meters a year at the margins to a maximum of 175 meters a year at the middle. Their results favor Lagally's opinion that the ice behaves as a viscous liquid. Shear zones develop near the tongue, and the upper part slides forward as a rigid body over the deeper layer.

The further contributions of this expedition are eagerly awaited.

FREDERICK K. MORRIS

### RESULTS OF THE TRINKLER CENTRAL ASIAN EXPEDITION

EMIL TRINKLER. **Geographische Forschungen im Westlichen Zentralasien und Karakorum-Himalaya.** viii and 133 pp.; maps, diagrs., ills. (Wissenschaftliche Ergebnisse der Dr. Trinkler'schen Zentralasien Expedition, Vol. 1.) Dietrich Reimer (Ernst Vohsen), Berlin, 1932. RM. 32. 12 x 9 inches.

HELLMUT DE TERRA. **Geologische Forschungen im Westlichen K'Un-Lun und Karakorum-Himalaya.** With appendixes by G. Fischer, W. Gothan, and others. x and 196 pp.; maps, diagrs., ills., bibliogr. (Wissenschaftliche Ergebnisse der Dr. Trinkler'schen Zentralasien Expedition, Vol. 2.) Berlin, 1932. RM. 44. 12 x 9 inches.

The first volume of the scientific results of the Trinkler Central Asian Expedition of 1927–1928 is the posthumous report of the leader. This volume is divided into two parts. Part I contains the "observations in the mountainous regions of Central Asia on the route from the upper Indus Valley over the west Tibetan highland to the Tarim basin, returning thence over the Karakoram to Kashmir." The observations are detailed in geographical order—first in the monstrous glaciated valleys of the Indus and its tributaries; then in the region of interior drainage of the Tibetan highland, the Tarim basin, and the huge mountain ranges of Kunlun, Karakoram, and Ladakh, with their intermontane basins.

The morphological history of the present land forms may begin with folding during early Tertiary time: uplift and faulting resulted in basin lands, presumably undrained, which received thick fills of continental sandstones and shales. Earth movements continued, and the Tertiary continental sediments are tilted and faulted. The region was peneplaned; then reëlevated and dissected until a system of deep and large valleys adjusted to the structure had been carved, during latest Tertiary time. Then began the glaciation. In some ranges the ice formed broad caps covering the moun-

tains from which monstrous valley glaciers streamed. Deglaciation and moderate redissection was followed by a second less severe glaciation, which has left the moraines and rock sculpture of the present day. Abundant lakes were formed and drained during the last recession.

The author finds peneplane remnants at about 6000 meters altitude. Many mountains have unglaciated uplands, deeply mantled in creeping residual soils, while many other mountains are of faceted alpine peaks. Below the peaks are cirques and hanging troughs overlooking the great master valleys. Within the valleys a series of high terraces include a rock shelf representing the preglacial floor and remnants of a firm conglomerate resembling Nagelfluh, which the author interprets as an early Pleistocene gravel related to the early, major glaciation. A lower series of benches is formed of moraines, lake clays, and river gravels, recording the advance and retreat of the later and lesser glaciers. During postglacial time the seaward-flowing streams have cut young canyons in unconsolidated sediments and even locally in the glacial rock floor.

Within the Tibetan highland are innumerable warped basins containing lakes. Dr. Trinkler draws a clear and correct distinction between the structural basin and the lake basin contained within it; they may have the same or very different histories, and each must be separately studied. The ranges are generally less imposing than in the region of ocean-going rivers. All of the lakes are shrunken, many lake beds are dry; and all show abundant shore lines. The younger lakes have fresh or slightly brackish water, the older ones are salty and bitter and wholly without life. Broad areas of salt clay and salt crust are described; but no tufas, limestones, oolites, or gypsum. Most of the rivers are choked with sediment, while others in recently upfaulted blocks are rejuvenated. The author infers large and recent changes of climate and of level.

In the second part the study of the western part of the Tarim basin is taken up. Much observed detail is added to our positive knowledge and confirms the views of Stein, Huntington, and Hedin as to changes in climate. The basin has warped downward along part, perhaps all, of its southern margin, and part of its former rainfall has been cut off by postglacial uplift of the giant fault blocks to the south.

The book is a genuine contribution to our knowledge of this difficult region and is written with scrupulous care to keep all inferences within the limits of the supporting facts.

Dr. de Terra's volume opens with an orographical review of the region from south toward north, the Himalaya and the Karakoram groups of ranges, the interior plateaus, and the western Kunlun ranges, and proceeds to the route geology—a substantial chapter of observations. A stratigraphic review of the rocks follows. Then come short chapters on the evolution of the present relief, on the tectonics of the western Kunlun, and on its place in the building of Central Asia. Six short supplements of paleontological and petrographic determinations by specialists conclude Dr. de Terra's volume. A report of progress, it is an orderly and serviceable statement of the results of field study and collection.

Both volumes appear in attractive guise and are well furnished with maps, sketches, and excellent photographic illustrations. Dr. Trinkler's volume includes a location map on the scale of 1:1,000,000.

FREDERICK K. MORRIS

## A MONOGRAPH ON PORTUGAL

H. LAUTENSACH. **Portugal: Auf Grund eigener Reisen und der Literatur.** Part I: **Das Land als Ganzes.** viii and 187 pp.; maps. *Petermanns Mitt. Ergänzungsheft No. 213*, 1932.

In the chapter on the historic and psychological basis of Portuguese cultural geography, Dr. Lautensach apologizes for "being obliged to bring man into con-

sideration" as if that were not geography, although he has considered geology, geomorphology, and climate without apology. As a matter of fact man does rather permeate the book, as this reviewer thinks he should, and we expect more and better in this respect from the promised special Part II.

It is man in a low stage of culture. The Portuguese are not progressive, not modern, nor are they even persistent in attempting to realize such improvements as they do get into their minds. On the contrary, they give up on encountering very moderate difficulties. The country is strewn with works and structures abandoned before completion or before a reasonable attempt to operate.

On the other hand what is old survives in many a corner, such as the communistic style of tillage in the northeast and the sharing of crops; and here the people still live in the rude stone-block houses on the old hill sites far up on mountain sides of Paleolithic times, the same high sites to which are limited the implements of Bronze-Age man. May not the curious costumes of the region belong to the same remote past? It is no place for new things, for three-fourths of the people cannot read. In the northwest, that core of densest population in Portugal about Oporto, the hill sites have been emptied and abandoned since Roman times as the Roman rulers made the poor and thievish highlanders come down and settle among the valley folk. The shrieking disk-wheel carts are said to be of design fully two thousand years old.

On the physical side Portugal is low; its surface averages less than 600 feet above the sea with all Iberia more than 2000 feet. Portugal stands by the sea, facing the winds that bring rain; hence it is wetter than Spain, and its people live especially by the seashore. Only in Norway are the fisheries more important to the country. The coastal fishermen are certainly, Dr. Lautensach says, descendants of the ancient Phoenicians—an old, old race.

The three great rivers enter on the east from Spain through gorges; floods, of course, raise their waters. Once in ten years a destructive flood may raise the water above these gorges as much as 80 feet. At Oporto, near the mouth of the Douro, the water in the harbor may rise 12 or 13 feet; but the great widening of the Tagus just above Lisbon—the Mar da Palha—takes up the flood water there with a rise of only a foot or two. Most of the people are farm folks with the worst methods and poorest crop yields imaginable. They have grown olives from time immemorial, and they still damage the fruit by beating it from the trees with poles, although even before the Christian era Varro told them not to.

What little commerce they have is mostly oversea. The 800-mile Spanish frontier is crossed by road or rail but once in an average of 80 miles. Only a small percentage of the imports and exports are across this land border. A curious chance gave this backward country a census of hearths (*fogos*) in 1527–1532, showing a national population of 1,250,000. This seems to have been the first census in Europe, antedating the early Swedish count by 250 years. Even at that time Entre-Douro-E-Minho had 20 per cent of the population on 8 per cent of the land, about as now. This was the densest settled part of the land,—a condition ascribed to the introduction of maize from Cadiz about ten years earlier; but this seems to the reviewer too quick a response. The birth rate is high, but the death rate is the highest west of Russia. Emigration, the lawful kind, is as prevalent as from Ireland, and there is much more that is secret to escape military service.

The railways are mostly of wide gauge, 5.47 feet in a land where thin population calls for narrow road structure and the heavy grades and sharp curves clamor for narrower gauge. Their first lines out of Lisbon were of standard width; but in 1859 they changed them to accord with Spain with whom they have insignificant business, using their deliberation to impose a hardship on national transportation. The author calls their railways not a net, but lines that some day might be built into a net.

Highways are imperfect, discontinuous, or lacking. One area south of the Tagus is 50 miles wide and 94 miles long and has no road, although well towards its center

is Ponte do Sor with 6700 inhabitants. Oporto and Lisbon see much more passenger traffic than they share in, for 249,000 passengers passed along in 1929 to 59,000 who went on board and 39,300 who came ashore.

Yet they have abundant raw materials that they do not develop; they have not risen to a cultural level above unskillful farming. Dr. Lautensach gives so much attention to the physical aspects of the Portuguese environment that the picture of the depressed state of Portuguese culture here given seems somewhat exaggerated, although it is all drawn from his pages. On the whole, it is a singular picture of a nation asleep to its opportunities and only waiting for general education to make use of them. The second volume with the author's personal observations will be waited with interest.

MARK JEFFERSON

## A HANDBOOK ON THE CANADIAN INDIANS

DIAMOND JENNESS. **The Indians of Canada.** x and 446 pp.; maps, ills., bibliogr., index. *Natl. Museum of Canada Bull. No. 65.* Department of Mines, Ottawa, 1932. $2.50. 10 x 7 inches.

This important publication is both a popular general treatise on Indian life in Canada and an informing handbook on the important tribes, a two-volume work in one. The general treatise occupies the first 264 pages. In the main, it is descriptive, dealing with data familiar to the reader of Indian subjects, but there are exceptions, as when the author expresses his interpretation of economic conditions. Thus, emphasis is given to the different footing of the colonist coming among the Indians, in that the former had a well organized nation behind him, with ready communication for recruiting personnel and goods, whereas an Indian tribe must be entirely self-sufficient. In the consideration of food, the author accepts the usual assumption that the density of Indian population was directly dependent upon the supply and so does not elaborate the case, also, as one must in such a treatise, lightly passing over the related assumption that the type of culture has much to do with determining the adequacy of a food supply and hence the density of the population. Throughout the chapters dealing with material cultures, the point of view seems to be that what the natives of Canada did was to make practical adjustments to the necessities of their environment. The winters in many parts of Canada were a severe trial to primitive man; his modes of shelter, however, seem reasonably adequate; his costume is mostly fur and skin but even so, excepting the Eskimo, far from adequate according to modern standards. Weaving was not practiced, except in a small locality in the Far West, and so does not play a rôle in costumes. The author says that the absence of suitable wools was the cause for this, a deficiency in the fauna. He might have added that felting was not known and that the nearest substitute for cloth was the woven blanket of strips of rabbit skin.

Agriculture was confined to so small an area that it can be ignored; hence at the time of white contact practically all aboriginal Canada was the home of more or less migratory hunters, and the types of shelter and transport conform to the needs of the place and the season. Had he so chosen, the author could have made much of the extreme seasonal changes in climate and consequent uncertainties in the local game supply, as determining the population and culture levels in aboriginal Canada. In matters of culture most things are relative; one might suppose that in a land of forests the fuel supply would be inexhaustible, but the author shows that with the aboriginal equipment for cutting wood and transporting it, a few months would use up the available supply in a locality and so render it uninhabitable for years. This alone would explain lack of permanent villages and dense populations in the greater part of Canada.

Turning from material culture to other forms, the author seems to reverse himself in stating that not only does the economic environment have nothing to do with

shaping the social life of the Canadian aboriginals, but that even in material culture it has but an insignificant rôle: this is, of course, asserting the view of contemporary anthropology in that "psychological and historical factors" are what count. The method of interpretation in the succeeding pages is then the usual one of tracing similarities among neighboring tribes. Social organization, religion, folklore, etc., are even more adequately described than material culture, though the general reader may find it more difficult to follow, because of the vagueness peculiar to all historical interpretations for culture.

Part II will be welcomed by all as a work of reference. All the important tribes, some forty in number, are taken up singly, and a reliable digest of available data is given. Furthermore, there are added data as yet unpublished or inaccessible to non-Canadian students. This is especially true of tribes in the Canadian Northwest. Those who use the Handbook of American Indians should always consult this volume for Canadian tribes, because errors and omissions in the former are often rectified in the present publication. The geographical student will find a number of new maps of culture areas, tribal ranges, language distribution, etc., all embodying the new data available. In passing, attention may be called to a mechanical error in the linguistic map which indicates the Gros Ventre as Siouan in speech, whereas they are Algonkian.

CLARK WISSLER

### PROBLEMS OF GLACIATION IN NORTH AMERICA

FRANK LEVERETT, with contributions by Frederick W. Sardeson. **Quaternary Geology of Minnesota and Parts of Adjacent States.** Investigations made in coöperation with the Minnesota Geological Survey. 149 pp.; maps, diagr., ills., index. *U. S. Geol. Survey Professional Paper 161*, 1932.

This paper is a notable contribution to our knowledge of the Quaternary geology and geography of North America. Leverett's long and varied field studies and his well known keen insight into the problems of the Pleistocene lend authority. The paper deals not only with Minnesota, where the complexity of glacial movements is well illustrated, but with a wide adjacent region. In fact, the main conclusions are based on studies, extending over many years, of much of the glaciated region from New York State to the Dakotas. Moreover, the paper reviews the main problems of the Pleistocene in North America and brings the discussion fairly up to date. There is a great deal of detail, particularly in the description of moraines, that is reminiscent of the monographs of former days and is rarely found in present-day writings. Contributions by Sardeson include a description of the moraines and other features of the Grantsburg sublobe of Wisconsin gray drift. Illustrations include two colored maps on the scale of eight miles to the inch and one of the vicinity of the outlet of Glacial Lake Agassiz on the scale of one mile to the inch, numerous black and white maps, and two photographic reproductions.

One of the problems discussed is the status of the Iowan drift. Briefly, the problem is whether the Iowan is the equivalent of the Illinoian drift on the east or is a distinct drift sheet. In other words, are there more than four drifts, the Nebraskan, Kansan, Illinoian, and Wisconsin being the well recognized ones, and is the Iowan a possible fifth or, according to the most recent views, a distinct part of the early Wisconsin? Proponents of the view that the Iowan is not the equivalent of the Illinoian and is a distinct drift sheet point out that the Illinoian drift has been modified much more by weathering and erosion than has the Iowan. Leverett questions this conclusion as not demonstrated and holds that it is natural to conclude that the Iowan is the probable correlative of the Illinoian. He, however, leaves the question open and concludes that further investigation is necessary to determine the relationship of the two drift sheets.

A return to the use of the term "Laurentide" ice sheet after many years disuse

except in some recent papers, is noteworthy, as its use implies that the eastern ice sheet, at its maximum, was essentially a unit; it had centers of dispersion dominant at different times. This appears to be Leverett's view. He uses the terms "Keewatin drift" and "moraines of the Patrician ice" as indicating dominance of these parts of the main ice sheet and partial withdrawal of other parts and apparently not as implying that the Keewatin ice formed a distinct sheet though at times there were extensive retreats of other parts.

Probably the most striking feature of the report is Leverett's contention that the growth of the Wisconsin Laurentide ice sheet was towards the west and that it reached its maximum extent in the west at the Missouri Coteau in late Wisconsin time when it had retreated in the east to the Great Lakes region. He tentatively correlates the Port Huron morainic system in the Great Lakes region with the group of moraines along the Missouri Coteau in the west. The gray drift of the Keewatin ice in the west is regarded as distinct from and somewhat younger than the red drift of the Patrician ice in the east, for "lines of glacial drainage lead from the gray-drift border across the red-drift area in a way which leaves no doubt that that part of the red-drift district was free from ice." Moreover, sections in one of the open pits of the Mesabi iron range (Plate 4 of the paper) show the two drifts as distinct. Some remarkable and perhaps improbable conditions resulted. Not only had the ice retreated far in the east when it was still expanding in the west, but a large part of the Superior highlands was free of ice when the Des Moines lobe was pushing far to the south to the limit of Wisconsin drift in Iowa. A difficulty in connection with the question of westward growth of the ice sheet is that, according to some writers, early Wisconsin drift of the Laurentide ice sheet extends to the west in northern Montana and southern Alberta beyond the Missouri Coteau group of moraines. If this is so, the maximum extent of the ice in the west was in early Wisconsin time and not in late Wisconsin time as held by Leverett. This problem, however, is not discussed in the report.

A minor point, which, however, may have considerable significance, is that Leverett holds that "gumbotil probably includes considerable material that was deposited on the till in interglacial time from atmospheric dust."

A section of the report deals with Glacial Lake Agassiz. Studies of the shore lines of this lake have been extended in northern Minnesota considerably beyond the limits mapped by Upham. Leverett and Sardeson's mapping of the shore lines differs somewhat from that of Upham. They find records of a glacial lake that existed prior to the formation of Lake Agassiz. Their interpretation of the morainic succession also differs from that of Upham in that a series of moraines was developed in a reverse order from that indicated by former workers. In connection with the history of Lake Agassiz Leverett points out that the greater part of the material forming the so-called deltas was contributed directly by the melting ice sheet. Many other points discussed in the paper are of interest.

W. A. JOHNSTON

### A STUDY IN THE COLORADO PLATEAU PROVINCE

HERBERT E. GREGORY AND RAYMOND C. MOORE. **The Kaiparowits Region: A Geographic and Geologic Reconnaissance of Parts of Utah and Arizona.** 161 pp.; maps, diagrs., ills., index. *U. S. Geol. Survey Professional Paper 164*, 1931. $1.05. 9 x 11¼ inches.

The Kaiparowits Region, taking its name from the broad plateau in its center, as included in this study, extends from Glen Canyon of the Colorado River in the southeast to the Paunsaugunt Plateau with Bryce Canyon in the northwest. Together with the San Juan country to the east and the adjacent parts of Arizona, this region is of unusual geologic interest and includes a variety of scenic marvels; but at the same time it is one of the most extensive isolated areas in the United

States. It is "essentially a country of broad cliff-edged mesas," intricately trenched by narrow steep-walled canyons. "Commonly one wide platform bench rises above another, and this in turn is surmounted by still others so as to form a series of broad irregularly outlined steps, each hundreds or even thousands of feet in height." Deviating from the normal sub-horizontal elements of the landscape are several "long monoclinal ridges, many of them sharply serrate." Much of the country is almost barren of soil and vegetation, as the climate is arid or semiarid, with only the highest plateaus having from 10 to 12 inches of rainfall, and with the rain commonly coming in torrents.

To readers of Gregory's "The Navajo Country" (*U. S. Geol. Survey Professional Paper 93*, 1917), the Kaiparowits study will stand as a sequel. The two studies are similar, as the physical features of the two contiguous areas are also similar. It is to be hoped that the authors will, as in the Navajo Country study, follow with a Water Supply Paper on the geography and hydrography of the region. Human occupation is still more restricted than in the Navajo Country, owing to meager resources and inaccessibility, with no railroad and only the northwest border of the 5400 square miles traversed by a through road. Five small settlements are the only permanent centers of population.

About half the report is devoted to the stratigraphy, giving detailed descriptions of the massive and colorful formations, and indicative of careful work, though the authors state "much of the work is reconnaissance—some of it exploratory." Of greater interest to the geographer is the chapter on the physiography. The drainage, remarkably discordant with the structures, the authors show quite conclusively to be superimposed rather than antecedent, as was generally inferred in earlier geological reconnaissances, especially by Powell and Dutton. The present stream courses are accordingly an inheritance from a consequent drainage system on Tertiary beds laid down in unconformity upon the already warped and eroded older beds. Remnants of mature older erosion surfaces on the higher plateaus in contrast to the canyon cutting of the present cycle, deeply incised meanders, trenching of alluviated canyon floors, are some of the complexities that indicate repeated changes affecting erosion and the surface features, which are in the last analysis primarily erosional.

J. W. HOOVER

### A PHYSIOGRAPHIC STUDY IN THE BASIN RANGE PROVINCE

RICHARD E. FULLER. **The Geomorphology and Volcanic Sequence of Steens Mountain in Southeastern Oregon.** Maps, diagrs., ills. *Univ. of Washington Publs. in Geology*, Vol. 3, 1931, pp. 1–130.

The reasoning we are obliged to use in searching for the causes of natural phenomena is persuasive rather than compelling, and consequently the conclusions reached are probable rather than certain. A common scientific method is the method of framing and testing hypotheses. If the consequences of a hypothesis, deduced according to accepted principles, agree with all the known relevant observations, the hypothesis is an adequate but not necessarily the unique solution. Another hypothesis may explain the same appearances equally well, or there may be unobserved effects with which the deduced consequences of the adopted hypothesis may not correspond. On logical grounds the conservative is always justified in withholding his acceptance of any hypothesis until it has explained a representative number of special cases, and even then he may rightly be sceptical if the hypothesis postulates conditions that appear forced or inherently unlikely. Thus, while the search for the causes underlying inadequately explained appearances may be regarded as the prime object of scientific study, it is hardly less important to test established hypotheses against new special cases and thereby increase their security or expose their weaknesses.

The security of the theory (established hypothesis) that the land forms of the Basin Range province result from the processes of arid erosion on faulted and tilted earth blocks lies in the complete correspondence between the logically deduced consequences of the postulated initial condition and the present observed appearances. Among theories of earth science the Basin Range theory is unusually well established through the rigorous deductive essays of Gilbert and Davis. The theory has, however, met with opposition, and in the reviewer's experience thoughtful young students are often resistant: they are, perhaps subconsciously, aware of the logical inconclusiveness of the results obtained by the method of framing and testing hypotheses, and they are not unreasonably troubled by the difficulty of disposing of the lower parts of tilted blocks and of imagining natural forces that will break an earth belt into a tilted stairway.

The Steens Mountain region provides a special case of tilted fault-block topography and one which is so recent and near to the initial stage postulated in the general theory that no one could reasonably contend that the theory postulates unlikely conditions or that the initial stage would not develop naturally into the somewhat maturer forms characteristic of much of the Basin Range province. The region lies on the east side of the Cascade Range near the northern limit of the Great Basin and not far from the Modoc Lava-Bed area recently described by the reviewer (*Geogr. Rev.*, Vol. 21, 1931, pp. 259–275). Like the northern part of the Modoc area, the Steens Mountain region consists essentially of little-dissected tilted tables of young volcanic rocks separated by depressions covered with alluvium and flat-floored or appearing relatively flat-floored in aspect. The lava tables are bounded by dominantly meridional escarpments, and there can be no reasonable doubt that the truncated lava series of the upstanding tables continue in depressed blocks underlying the alluvium of the intervening depressions. It is correspondingly certain, therefore, that the escarpments are fault-line scarps representing differential vertical movements exceeding the amount (up to 5500 feet) by which the horsts rise above the grabens.

In a theoretical introduction Fuller restates his previously published arguments against the view of W. D. Smith who explained the block-fault structure of Oregon as the result of lateral compression. The thrust-fault hypothesis, approved in principle by E. J. Wayland and Bailey Willis is equally untenable in the Modoc region. In regard to the age of block faulting Fuller gives no definite conclusions; but from his descriptions and correlations it would seem that, as in the Modoc area, the displacements represent numerous movements that occurred in late Pliocene, Pleistocene, and Recent times. Fuller's descriptions would be more easily followed with the help of a more detailed map than that given; they are splendidly illustrated, however, by photographs, many of them aerial obliques, which constitute in themselves most striking testimony of recent regional block faulting.

M. A. Peacock

## Alpine Mount Washington

Ernst Antevs. **Alpine Zone of Mt. Washington Range.** viii and 118 pp.; maps, ills., bibliogr., index. Merrill and Webber, Auburn, Me., 1932. $2.00. 7½ x 5½ inches.

This little volume covers a rather wide range of features and includes studies on Mt. Katahdin as well as those on the Mt. Washington Range, made in the summer of 1928. The title "Alpine Zone" leads one to expect a treatment of climate, flora, and fauna; and these subjects are given a full consideration. The peculiar effects of frost action in developing nets and polygons of frost-moved stones is well described, as well as the physical weathering of the surface rocks produced by the great changes in temperature.

As these mountains fall within the limits of the Laurentide glaciation and were also of sufficient altitude to support local glaciers, the relation of the local glaciation to the continental glaciation is of especial interest. Goldthwait some twenty years ago had interpreted the cirques in the Mt. Washington Range to antedate the coming of the last or Wisconsin continental ice sheet. But Douglas Johnson in 1917 brought out evidence that there was local glacial erosion after the last withdrawal of the continental ice sheet. Studies in the Catskills and Adirondacks and on Mt. Katahdin were also interpreted to show a similar relation of local to continental glaciation. Antevs has devoted a chapter to this question; and, while agreeing with Johnson that there has been local glacial action subsequent to the culmination of the last continental glaciation, he makes the suggestion that the cirques were formed by repeated glacial action in connection with each of the glacial stages of the Pleistocene and during the oncoming as well as during the decline of each glaciation. If there were four glacial stages there would be eight potential times of cirque cutting. The great size of the troughs connected with the cirques seem to him to demand such repeated local glacial action.

The volume closes with a bibliography of 250 references, covering the several subjects discussed. The work was done under a grant from the American Geographical Society.

FRANK LEVERETT

## THE LEGEND OF GOG AND MAGOG

ANDREW RUNNI ANDERSON. **Alexander's Gate, Gog and Magog, and the Inclosed Nations.** viii and 117 pp.; bibliogr. (Medieval Academy of America, Publication No. 12 (Monograph No. 5).) Cambridge, Mass., 1932. $3.00. 10¼ x 7 inches.

"And when the thousand years are expired, Satan shall be loosed out of his prison, and shall go out to deceive the nations which are in the four quarters of the earth, Gog and Magog, to gather them together to battle: the number of whom is as the sand of the sea" (Revelation xx, 7-8). This dread prophecy and its counterpart in Ezekiel are the fountainheads of a great stream of legendary lore that flowed down through ancient and medieval centuries in the Western World and the world of Islam alike. With sound scholarship Professor Anderson traces the complex but fascinating course of this stream and its many tributaries and interlacing branches.

One of the main tributaries rose in tangled thickets of mythology that had sprung up around the exploits of Alexander the Great. In the Caspian mountains Alexander was reputed to have built a mighty rampart and a gate of iron and brass, shutting out the barbarians—Scythians, Alans, Huns. Early in the Christian era these and other wild tribes came to be identified with Gog and Magog of the Bible, and Alexander was pictured as "a worshipper, a champion, and an instrument of God," building a wall and gate in defense of civilization against the northern scourge. "The legend . . . is in reality the story of the [eternal north European and Asiatic] frontier in sublimated mythologized form."

About the twelfth century the Ten Lost Tribes of Israel were drawn into the legend in association with Gog and Magog and the hordes whom Antichrist would lead forth to ravage the world at the Day of Judgment. Through the channel of a sixth-century book of revelations known as the Pseudo-Methodius the story found almost universal currency in the West. The influence of the Pseudo-Methodius is said to have been "second only to that of the Canon and the church fathers."

In the Koran the building of the gate is celebrated as the crowning deed of Alexander, or Dulcarnain, the two-horned. During the ninth century Caliph Al-Wathik-Billah sent out a certain Sallam the Interpreter to find the wall of Dulcarnain. Failing to discover it in the Caucasus, Sallam pushed on into the heart of Asia, where he came upon the object of his search, a mighty rampart and ponderous gate blocking

a narrow pass between two mountains. Edrisi (or Idrisi), Moslem geographer at the Sicilian court of Roger II, "charted Dulcarnain's wall in accordance with Sallam's report," and "it is probable that Idrisi's map was the determining influence that caused a number of later occidental maps to [place] Gog and Magog in the far east or northeast." Gog, Magog, and Alexander's gate were destined to linger on in European cartography until well into the seventeenth century. "The Gate itself had wandered from the Caspian Gates . . . even as far as remote eastern or northeastern Asia, gathering in strength and increasing in size as it went, and actually carrying the mountains of Caspia with it. Then, as the full light of modern day came on, the Alexander Romance ceased to be regarded as history, and with it Alexander's Gate passed into the realm of fairyland."

## Ptolemy's Geography

Edward Luther Stevenson, transl. and edit. **Geography of Claudius Ptolemy.** Based upon Greek and Latin Manuscripts and Important Late Fifteenth and Early Sixteenth Century Printed Editions, Including Reproductions of the Maps from the Ebner Manuscript, *ca.* 1460. With an Introduction by Joseph Fischer. xvi and 167 pp.; 29 double plates; maps, diagrs., facsimiles. New York Public Library, New York, 1932. $60.00. 17 x 12¼ inches.

Among the Greeks Ptolemy (*ca.* 150 A. D.) ranks second only to Aristotle in the influence that his writings exerted upon the later development of science. For nearly fourteen centuries the concept of astronomy set forth in the "Mathematical Composition" (or "Almagest") stood unchallenged. His other outstanding work, the "Geography," formed the basis of the cartography of the Moslems during the Middle Ages. While generally neglected in medieval Christendom, it was recovered during the Renaissance, when it was often translated into Latin. The humanists of the fifteenth and sixteenth centuries looked to the "Geography" for information about classical lands, and the cartographers of the period used it in drawing their maps of the contemporary world.

The volume under review is the first complete translation of Ptolemy's "Geography" that has appeared in any modern European language. The binding, typography, and paper are superb and reflect much credit on the New York Public Library. Only 250 copies were printed; and the price, $60.00, is unfortunately beyond the means of most scholars. Besides Dr. Stevenson's translation the volume includes an introduction by Professor Joseph Fischer and a group of magnificent reproductions of Ptolemaic maps of the Codex Ebnerianus belonging to the New York Public Library. The Introduction would have benefited by further editorial attention, as the meaning is not everywhere clear.

Ptolemy's interest in geography was almost wholly mathematical and cartographic. His aim, as he himself expressed it, was to "distinguish . . . the various prefectures, and provinces of the earth, treating them . . . in accord with the known positions of localities . . . , spurning the multitudinous traditional farrago concerning the peculiar qualities of their different inhabitants, except that, in the case of qualities renowned by general report, we make a short and suitable note on the religion and manners."

Book I of the "Geography" consists of a general discussion of the nature of geography, a critique of the work of Ptolemy's predecessor, Marinus of Tyre, and an explanation of map projections. The following books are devoted almost entirely to tables of the latitudes and longitudes of some 8000 localities. Many manuscripts of the "Geography" are accompanied by a map of the world and by regional maps—in some cases twenty-six and elsewhere sixty-four in number. Among recent students of the "Geography" some have maintained that none of these maps can be ascribed to Ptolemy. It has even been denied that Ptolemy made any maps what-

soever to accompany his text. Professor Fischer in his Introduction presents convincing arguments to the effect that the regional maps "essentially belong to the Geography of Ptolemy, and offer with essential accuracy the original Ptolemy maps." The world map, however, is ascribed to an Alexandrian geographer, Agathodaemon.

Owing to its strictly mathematical character the "Geography" lacks the broad, popular interest of some of the other geographical writings of antiquity. Its hard, dry, technical quality explains, in part, why for so long it has escaped translation into a modern tongue. Another difficulty has been offered by the lack of an adequate critical edition of the Greek text. Dr. Stevenson explains that his translation is "based upon the generally recognized best Latin and Greek texts, and . . . upon the critical texts and studies of Wilberg and Müller." Wilberg's text dates from 1838 and that of Müller in part from 1883 and in part from 1901; neither is complete or satisfactory. No one has yet attempted the herculean task of analyzing all the manuscripts with their variations and of establishing a standard version for the whole work on the basis of such analysis. Dr. Stevenson has made "no special attempt . . . to pass upon the relative merit of the variations" as between different manuscripts and early printed editions. In each case he has selected the reading that has seemed to him the preferable one. Until a definitive text appears this is about all that any translator could do. It means, however, that no translation can be safely used as a basis for detailed research, since the reader has no assurance that either the meaning of phrases, the spelling of names, or the figures for geographical coördinates come as close to those of Ptolemy as they can be brought.

To the scholar who understands its limitations and uses it with due caution Dr. Stevenson's translation will be helpful. Its primary service will be to provide a short cut whereby readers lacking a thorough grounding in Greek can obtain a general idea of the content and quality of Ptolemy's work. Graduate students specializing in geography could do no better than to study Book I in order to familiarize themselves with the keenly critical and creative mind of one of the outstanding figures in their chosen field. It is to be hoped that a much less costly edition may be prepared in order that a wider circle of students may be reached. Such a translation would serve its purpose if most of the tables were omitted, only enough being retained to suggest their general character.